



**‘To Be or not to Bee’
Lesson Study in Early Years Education: What are the
characteristics of an effective STEAM lesson?**

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Bachelor of Education (Hons)

Submitted for Award of Masters

Word Count: 28,068

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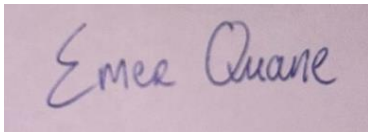
Submitted to: Mary Immaculate College, University of Limerick in fulfilment of the requirements of the Research Masters in Education.

July 2024

Declaration

I hereby declare that this thesis represents my own work and has not been submitted, in whole or in part, by me or another person for the purpose of obtaining any other qualification.

Signed:

A rectangular box containing a handwritten signature in blue ink that reads "Emea Quane".

Date: 18/06/24

Acknowledgements

My journey through completing a postgraduate dissertation has been an enjoyable and academically enriching experience. There are many who helped, guided and supported me on this journey, and I would like to take a moment to thank them.

First, I wish to thank Dr. Aisling Leavy. I would like to express my deepest appreciation to her for invaluable advice and continuous support. Her immense knowledge and plentiful experience have encouraged me in all the time of my academic research and daily life.

To the principal and class teachers who facilitated and engaged with the lesson study, thank you for your time, patience, and hard work.

Finally, I would like to express my gratitude to my family and Martin, for their encouragement, support, and joy throughout my studies.

Abstract

‘To Be or not to Bee’ Lesson Study in the Infant Classroom: What are the characteristics of an effective STEAM lesson?

Emer Quane

This study investigates the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) in early years education using the innovative approach of lesson study. The aim of this research is to explore the characteristics of effective STEAM lessons in early years education, in an urban, junior primary school. Through a collaborative lesson study framework, educators collaboratively design, implement, and reflect upon STEAM-infused lessons, tailoring them to the unique developmental needs of 5–7-year-olds. The two teacher participants engaged in six lesson study cycles over the course of four months. Lesson study was used as a vehicle to implement STEAM lessons in two senior infant classes. Qualitative data was collected through semi structured interviews, lesson plans, and observations. Preliminary findings showcase a positive impact of STEAM in early years education and outline effective pedagogies and methodologies used. Furthermore, the findings illustrate how lesson study offers a conducive platform for educators to co-create developmentally appropriate STEAM experiences. Collaborative lesson planning and iterative refinement contribute to the design of engaging STEAM activities that facilitate young children’s STEAM experiences. However, challenges related to teachers changing practice and teachers lack of confidence in teaching STEAM in early years education were identified. Furthermore, the study highlights the significant impact of professional development for educators to effectively implement STEAM education. The work concludes by contemplating the place of STEAM education and lesson study in the current educational landscape and makes recommendations to support their implementation nationally.

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List of Abbreviations

BTYSTE:	BT Young Scientist and Technology Exhibition
CLR:	Collaborative Lesson Research
CLS:	Creative Learning Spiral
CPD:	Continuous Professional Development
DEIS:	Delivering Equality of Opportunity in Schools
DES:	Department of Education and Science
DPSM:	Discover Primary Science and Mathematics
DYCA:	Department of Children and Youth Affairs
ECE:	Early Childhood Education
EDP:	Engineering Design Process
ICT:	Information and Communications Technology
INTO:	Irish National Teachers' Organisation
ITE:	Initial Teacher Education
LS:	Lesson Study
LSP:	Lesson Study Process
MEST:	Ministry of Education, Science, and Technology
MIREC:	Mary Immaculate Research Ethics Committee
NCCA:	National Council for Curriculum and Assessment
NPMC:	New Primary Mathematics Curriculum
NQT:	Newly Qualified Teacher
NRC:	National Research Council
OLS:	Online Lesson Study
PCK:	Pedagogical Content Knowledge
PD:	Professional Development
PDST:	PD Service for Teachers
PISA:	Programme for International Student Assessment
PLC:	Primary Language Curriculum
PMC:	Primary Mathematics Curriculum
PSC:	Primary School Curriculum

- SEN:** Special Educational Needs
- SFI:** Science Foundation Ireland
- STEAM:** Science, Technology, Engineering, Arts and Mathematics
- STEM:** Science, Technology, Engineering and Mathematics
- TIMSS:** Trends in International Mathematics and Science Study
- UDL:** Universal Design for Learning
- WCD:** Whole Class Discussion

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Chapter 1: Introduction

1.1 Introduction

The purpose of this study is to gain insight into the characteristics of an effective STEAM lesson in the early years' education. The study has been designed using lesson study (LS) as a vehicle to explore various STEAM pedagogies and teacher's experience of such. The focus of the LS involved designing, refining, implementing, revising and finalising six STEAM lessons in two senior infant classes. The findings from the research reveals the characteristics of an effective STEAM lesson in Early Childhood Education (ECE) and the development of teacher's understanding, skills and knowledge of STEAM education through LS.

This chapter outlines the purpose of this research through discussion of the elements which gave impetus to the study. To begin, the research question and embedded questions are outlined. National and international contexts regarding STEM and STEAM are briefly summarised, with a particular focus on Irish policy. A succinct introduction to LS is provided as it provides the structure framework to the study. Additionally, the research's originality and autobiographical background are displayed. Finally, this chapter gives the thesis an organisational framework by describing the goal and composition of each chapter.

1.1.1 Research Question

The main research question guiding the study is:

What are the characteristics of an effective STEAM lesson in Early Childhood Education?

1.1.2 Embedded Questions

The embedded questions for this study are:

- In what ways does teachers' practice in STEAM change (if at all) as a result of engaging with Lesson Study?
- What are teachers' understanding, skills and knowledge of STEAM education?
- What are Irish teacher's experiences and opinions on Lesson Study as a form of CPD?

1.2 STEAM Education

An increasing movement to enhance STEAM (Science, Technology, Engineering, Arts, and Mathematics) education both nationally and internationally has been visible over the past ten years. The focus on integrating the arts into STEM (Science, Technology, Engineering, and Mathematics) education is what distinguishes this rapidly evolving field. Despite the popularity of STEAM education and the abundance of STEAM-related activities, there is significant variation in how STEAM is conceptualised, understood, and used in educational undertakings (Leavy, Carroll, Corry, Fitzpatrick, Hamilton, Hourigan, LaCumbre, McGann and O'Dwyer 2022).

Advocates for STEAM education recognise that STEAM education has the power to enhance student learning, and they present strong justifications for institutionalising the importance of the arts in STEM education. Many argue the integration of the arts has the potential to make STEM more accessible to potentially marginalised students. However, with this perspective STEM is given increased prominence, and the function of the arts in STEM is seen as integrating with STEM to advance STEM learning (Leavy et al. 2022). Others value STEAM

and STEM as co-equal wherein this approach to STEAM education uses arts integration as an instructional strategy, giving students many entrance points into the creative process and achieving the learning goals of both the arts and STEM courses.

Whilst Ireland has published a STEM Education Policy Statement (DES 2017a), there is no Irish STEAM policy. However, this STEM policy emphasises the benefits of integrating STEM and the arts. Notably a STEM and the Arts Advisory group was formed as a sub-group of the Department's STEM Education Implementation Advisory Group. The STEM and the Arts Advisory Group's primary responsibility is to provide advice to the STEM Education Implementation Advisory Group on the oversight, development and delivery of relevant STEM and the Arts actions within the STEM Education Implementation Plan. The STEM and the Arts Advisory Group commissioned a literature review as part of this work that focuses on studies in the national and international educational context and identifies major obstacles and facilitators to the adoption of successful STEM and the Arts education in both formal and informal settings. This literature review was published in 2022 (Leavy et al. 2022).

1.3 Irish Policy on STEM Education

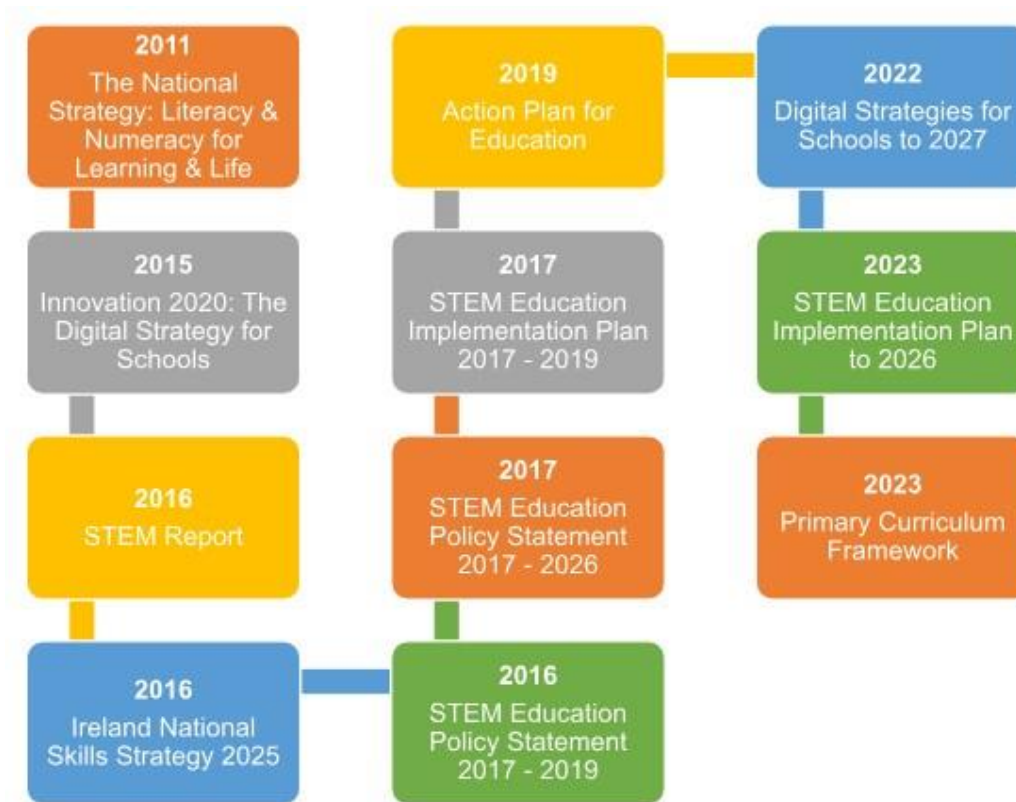


Figure 1: Policy Timeline

STEM is an acronym for science, technology, engineering and mathematics. STEM education resides on the idea of educating children in these four areas using an integrated approach, over teaching the four disciplines individually. At present, there is considerable ongoing change regarding STEM policy in Ireland. For several years now, progressive governments around the world have placed a high priority on promoting STEM policy and raising the standard of STEM education. Economic competitiveness is thought to be solved by STEM, hence giving reason to the production of numerous government plans, policies, and reports.

As a result of this competition realisation, many countries have developed STEM policies to guarantee high-quality education.

Regarding policy, the Literacy and Numeracy for Learning for Life (DES 2011a) strategy has pushed STEM education out of its shadow. With this tactic, a vision for reading and numeracy was provided. The publication provided a comprehensive list of goals and recommendations on how to increase literacy and numeracy levels, including more time dedicated to teaching these subjects. In this document, numeracy and digital skills also received notable attention for children. Although STEM is not mentioned in this text, there were concerns regarding declining interests in STEM disciplinary subjects and the corresponding need to develop a STEM workforce. In order to assess STEM education in Ireland, the STEM Education Review Group was later founded (Leavy et al. 2020).

STEM policies have been more prevalent in recent years, with the introduction of *Innovation 2020*, *The Digital Strategy for Schools (2015–2020)* (DES 2015a), *Action Plan for Education (2016a)* *STEM Education in the Irish School System: Report of the STEM Education Review Group* (MacCraith 2016), the *STEM Education Policy Statement* (DES 2017a) and *The STEM Implementation Plan (2017a)*. *Innovation 2020* promoted STEM education at all levels of the educational system. The goal of the *Digital Strategy for Schools* was to integrate technology into teaching, learning, and assessment over the course of five years (DES 2015a).

The STEM agenda in Ireland underwent significant developments in 2016 (Leavy et al. 2020). In 2016, the *Action Plan for Education (2016b)*, cited STEM as a crucial area for review and advancement. The development of a national STEM policy was given priority, and the STEM Education Review Group's advice was to be carried out. Particular focus was

placed on encouraging more women to pursue STEM fields and developing strategies to close the skills gap. Additionally, *STEM Education in the Irish School System: Report of the STEM Education Review Group* (2016) was introduced with a vision to provide Irish students with a STEM experience of the highest international quality (MacCraith 2016). The MacCraith (2016) report offers various suggestions for promoting STEM education in primary schools and acknowledges the need for PD in the area of STEM education. The STEM Education Policy Statement (DES 2017a) was developed in response to the findings of this STEM Education Review Group study. Notably, the strategy covers early childhood through post-primary education (see figures 1, 2). This is the first time STEM skills have been identified as a focus in Early Childhood Education (ECE).

Early Childhood themes, Primary priorities, Junior and Senior Cycle Key Skills						
Level 4	Senior Cycle keyskills ⁶	Critical and creative thinking	Communicating	Information processing	Being personally effective	Working with others
Level 3	Junior Cycle keyskills ⁷	Managing information and thinking	Being Literate Being numerate	Communicating	Staying well Being creative	Managing myself Working with others
Level 2	Primary priorities ⁸	Develop thinking, learning and life skills	Communicating well	Be well	Engage in learning	Have a strong sense of identity and belonging
Level 1	Early childhood themes ⁹	Exploring and thinking	Communicating	Well-being		Identity and belonging

Figure 2: Early Childhood Themes, Primary Priorities, Junior and Senior Cycle Key Skills (DES 2017a)

For early years settings/schools

- STEM education will be an integral part of the culture, policy and practice of our early years settings and schools
- Leaders in all early years and school settings will foster a culture of scientific and technological innovation to promote creativity in STEM teaching and learning
- All early years settings and schools will be supported to establish relationships with STEM business and industry, public sector bodies, research organisations, further and higher-level institutions, and the wider STEM community
- All early years settings and schools will foster a culture of collaboration for professional learning in STEM education
- All schools will engage with parents, learners and the community in communicating the value of STEM education and STEM careers

Figure 3: STEM Education Goals for Early Years Settings/ Schools (DES 2017a)

The areas of policy development and action in the STEM Education Policy Statement (DES 2017a, p.14) span four pillars: Nurture learner engagement and participation (pillar 1), Enhance early years practitioner and teacher capacity (pillar 2), Support STEM education practice (pillar 3) and Use evidence to support STEM education (pillar 4). The outcomes for Pillar 2 for early years practitioners mention a STEM professional development programme, the embedment of STEM into their teaching practise, and the adoption of an inquiry oriented and cross disciplinary approach. Pillar 2 links closely to this study.

The new Primary Curriculum Framework in Ireland, launched in March 2023, represents a significant overhaul of primary education. It is a comprehensive curriculum designed to modernise and enhance learning, teaching and assessment. A notable key feature of the new curriculum includes Science, Technology and Engineering (STE) Education. As part of the broader redevelopment of the primary school curriculum, a new draft specification for STE education has been released (NCCA 2024).

STEM is widely acknowledged as being essential to economic growth. The emphasis on STEM in the new curriculum reflects Ireland's commitment to preparing students for a technologically advanced and scientifically oriented world. The various strategies' ambitions and visions must be transformed into educational initiatives and subsequently into actual

practises. To progress STEM beyond policy and into practise, it is essential that it continue to be a top educational priority. Similarly, the same importance should be applied to STEAM education initiatives to aid its progression and development.

1.4 Lesson Study

In the realm of curriculum change and reform, the imperative for robust teacher professional development (PD) cannot be overstated (Flanagan 2021). When considering new and dynamic curricular domains, where there are little research-informed practices, PD is vital in supporting and informing such changes. Such is the case with STEAM education in ECE, where innovative approaches to integrating the disciplines necessitate tailored support for educators. By investing in comprehensive PD, teachers can not only navigate new educational areas but also forge pathways for meaningful change within their classrooms, ultimately fostering a rich and engaging learning environment for young minds. LS is a classroom-based form of PD that allows teachers to trial and test lessons and new pedagogies with the support of their colleagues (Lewis and Perry 2014).

LS is a professional development (PD) paradigm that promotes teacher collaboration in the planning, carrying out, observing, and reflecting on practises related to teaching and learning (Flanagan 2021). First, a research lesson is carefully planned by teachers working together. This necessitates time set aside for intensive 'kyozai kenkyu', a procedure in which teachers explore every facet of the material to be taught and the instructional resources available together (Fernandez 2002; Lewis 2002a). One teacher teaches the class while the others observe and record the students' learning, engagement, and behaviour. Team members collect

information on students learning, maybe examining a few to see how their thinking develops and discovering any obstacles to learning (Lewis et al. 2012). After the lesson, everyone participates in a post-lesson review called 'jyugyo kentuikai' (Fernandez 2002; Lewis 2002a). The lesson is then discussed and revised by the teachers in light of their observations, and it is then taught again to a new group of students. Participants watch as the instruction is repeated. Teachers come together once again to reflect and go over the information on student and teacher learning (Lewis et al. 2012). Teachers identify implications for the topic-specific teaching and learning as well as for teaching and learning more generally.

1.5 Original Contribution of this Research

The STEM and STEAM education policy and context discussed above illustrates the increasing need to understand and locate STEM and STEAM in Irish primary schools, particularly in the junior end.

The Irish government has made STEM education a priority, therefore this research is both timely and relevant. As of now, STEM research in Ireland has primarily concentrated on upper primary school science classrooms and primary scientific education as a whole (Flanagan 2021). As a result, research into STEM education is still in its early phases, leaving a gap in our understanding that needs to be filled. To support and help educators in adapting to STEM or STEAM education, targeted bespoke PD is necessary (O'Dwyer, Hourigan, Leavy, and Corry 2023). Therefore, it is critical to identify and utilise effective PD delivery methods. Additionally, there are few studies on the opinions of Irish primary teachers about LS and STEAM education. In an urban Irish primary school with students in senior infants, this research intends to investigate the characteristics of effective STEAM lessons through the use of LS.

1.6 Rationale

My professional journey has been a constant source of inspiration for this research. This study is a culmination of my diverse interests and unwavering passions. During my time as an undergraduate student, I specialised in Mathematics education and embarked on a transformative learning journey within a LS cycle on STEM education. Though this experience was disrupted by the Covid-19 pandemic, my enthusiasm for it never waned. I knew that I wanted to not only continue but also complete this journey. After college, I found myself in the role of a mainstream class teacher in an urban junior school, where I taught senior infants for two years. This experience ignited my fascination with early years education. It's a phase of learning where curiosity and interest are at their pinnacle, waiting to be nurtured. As someone who excelled in school, particularly in Mathematics and the Sciences, I was never encouraged to consider STEM careers. However, as I delved into college coursework and explored the world of STEM and STEAM education and the persisting gender disparities in STEM careers, it resonated deeply with me and captured my interest. My passion now lies in educating our youngest learners in STEAM, with a particular focus on young females. I am driven by the belief that we must provide enriching experiences that unlock their potential, cultivate their curiosity, and ignite lasting interest. I envision a future where they not only consider, but excel in, these fields, driven by their own curiosity and ignited passion.

1.7 Structure of the Thesis

Chapter 1 briefly introduced the study. It outlined the research question and embedded questions before detailing the pertinent policies and contexts that guided the study. Finally, it outlined the distinctive contribution of this study and provided the rationale for the focus on STEAM education in ECE and use of LS. The review of the literature is divided into two

chapters that analyse the research on LS and STEAM education. Chapter 2 addresses LS and discusses national and worldwide LS practises. Chapter 3 illustrates existing literature on STEM and STEAM education, the integration of the STEAM disciplines, STEAM in ECE and teachers and STEAM education. Chapter 4 outlines the research design along with the data collection and analysis procedures. Chapter 5 showcases the findings of this study under four themes: (1) Teacher's Progression of Understanding, Teaching and Value in ECE STEAM, (2) Fostering Autonomy and Inquiry in Early Education STEAM, (3) Effective ECE Pedagogies for STEAM Learning and (4) Navigating LS: Benefits and Challenges for Educators. Chapter 6 places the findings within the context of the body of literature for analysis. The concluding chapter restates the premise, summarises the findings, identifies the study's limitations, and provides recommendations for teachers, principals, policy makers, and research.

Chapter 2: Literature Review on Lesson Study

2.1 Introduction

This chapter is divided into four sections that each explore a different piece of relevant literature for this subject. The initial section gives an overview of lesson study (LS), the LS process and plan. Subsequently, literature regarding the benefits of LS is discussed before moving on to section three, LS globally. As this study was undertaken in Ireland on STEAM

education, the final section explores LS in the Irish educational context, with a particular focus on primary mathematics and STEM education.

2.2 Lesson Study Overview

Lesson study (LS) originated from Japan (Quaresma et al. 2018). Origins have been traced back to the early 1900's and Konaikenshu (the newer practice) since the 1960's (Fernandez and Yoshida 2004). Research states that once the value of engaging in lesson study practice became evident, the Japanese government assisted financially, and now in Japan the vast majority of elementary school's practise lesson study voluntarily (Fernandez and Yoshida 2004). It is a 'school - based research method for securing consistency between learning goals and teaching methods' (Elliot 2019, p.1). LS gives teachers a clear view of their strengths and weaknesses allowing them to improve their practice (Fernandez and Yoshida 2004). It is highly valued as a form of professional development and has the potential to be a critical tool in supporting educational change (Fernandez and Yoshida 2004). Recently efforts are being made for teachers to use LS as a site for Professional Development (PD) (Fernandez and Yoshida 2004, Quaresma et al. 2018). While the lesson study process can be used in any curricular area, research shows it is used mainly in mathematics education (Quaresma et al. 2018).

Dudley (2012) concludes that LS is a valuable method in teacher learning. Evidence is provided proving that implementing LS can enhance teaching, learning, and student outcomes across various school settings (Dudley 2012). The success of LS hinges on a system that encourages teachers and school leaders to enhance their expertise through structured, collaborative, and inquiry-based learning approaches (Dudley 2012). However, policy makers face the challenge of making research easily available to teachers engaged in lesson studies (Dudley 2012). This is important to prevent them from duplicating efforts that have already

been made and to ensure that their initiatives are based on approaches supported by research evidence (Dudley 2012). Additionally, in a culture where sharing teaching practices is not common, there is a need to support teachers in publishing their lesson studies and accessing an expanding database of such studies to enhance their own PD in schools (Dudley 2012).

2.2.1 Lesson Study Process

Lesson Study can occur at various levels depending on its goal (Lewis and Takahashi 2013; Takahashi and McDougal 2016). These include School-wide Level, District Level, Nationally Designated Research Schools and Association Sponsored Lesson Study. School-wide Level involves teachers at similar class levels coming together to plan and execute one or two research lessons. These lessons are centred around school-wide research themes. District Level is when local groups typically meet monthly and conduct semi-annual research lessons. In Nationally Designated Research Schools, teachers not only teach children but also engage in studying curriculum and instructional methods for nationwide dissemination. The research lessons conducted in these schools are made public. Finally, Association Sponsored Lesson Study is when small interest groups gather to discuss their teaching practices. During these conferences, members observe and discuss research lessons based on themes chosen by the group (Curran 2020; Lewis and Takahashi 2013; Takahashi and McDougal 2016)

The Lesson Study Process (LSP) involves collaboratively planning the study lesson, seeing the study lesson in action, discussing the lesson study, revising the lesson study (optional), teaching the new version of the study lesson (optional), and finally sharing reflections (Fernandez and Yoshida 2004).

2.2.2 Lesson Study Plan

A LS plan template is a structured tool used to guide educators in collaboratively developing and refining a lesson (Lewis and Tsuchida, 1998). It typically starts with a clear title and outlines the objectives for the lesson. It includes a section for specifying the learning goals for students, ensuring alignment with curricular objectives. The template also shows the sequence of activities within the lesson. Additionally, it features a segment dedicated to listing the instructional materials, technology, or other resources required for the lesson (Fernandez and Yoshida, 2004). Anticipated student responses or potential misconceptions are addressed in a designated section, allowing educators to proactively handle potential challenges. Furthermore, there is a section for reflection and assessment, enabling teachers to evaluate the lesson's effectiveness and adjust for future iterations (Lewis and Tsuchida, 1998). In essence, a well-structured LS plan template serves as a comprehensive guide for educators to collaboratively design, implement, and refine instructional strategies, ultimately enhancing student learning outcomes (Fernandez and Yoshida, 2004).

Learning Activities and Questions	Expected Student Reactions	Teacher Response to Student Reactions	Evaluation

Table 1: Lesson Study Planning Template

Fernandez and Yoshida (2004) provide an explanation of what a sample lesson study plan should include. The first column is for an explanation of learning activities, key questions to

ask at different points, and includes verbatim lines for teachers. The second column describes ideas, answers and includes teachers' predictions of what students might say. The third notes how to respond and things for teachers to remember and the fourth is running commentary about how the teachers will assess the success of different parts.

Whilst this is an example of one LS plan template, LS templates can vary between countries due to differences in their educational systems and cultural contexts (Lewis 2002). While the core principles of LS remain consistent - involving collaborative planning, classroom observation, and reflection - the specific templates may differ based on the goals and needs of practitioners within each country (Lewis and Tsuchida 1998). For instance, Japan has its own established practices and templates (Fernandez and Yoshida, 2004). When other countries adopt LS, they often modify the process to suit their unique educational contexts and goals, leading to variations in the templates used (Lewis 2002). Notably, while the fundamental concept of LS is universal, specific templates and approaches may vary from one country to another. Educators may customise templates to better align with their local curriculum, teaching methods, and educational objectives (Fernandez and Yoshida 2004).

2.3 Lesson Study Facilitation

Facilitating lesson study requires a skilled individual capable of coordinating a collaborative process aimed at enhancing teaching and learning. The facilitator plays a crucial role in guiding educators through every stage of the lesson study cycle, including planning, implementing lessons, analysing outcomes, and refining instructional strategies (Lewis, 2004). They establish a structured framework for team meetings that promotes open dialogue and nurtures a culture of inquiry and reflection among participants (Stigler & Hiebert, 2009). Facilitators often bring expertise in educational research methods and pedagogical approaches, which allows them to offer valuable insights and resources that support teachers' professional

growth (Lewis, 2002). Additionally, they ensure that the lesson study process remains focused on its objectives of improving student learning and fostering educators' professional development (Fernandez, Cannon, & Chokshi, 2003). By fostering a collaborative environment where educators can exchange ideas, provide constructive feedback on each other's work, and experiment with innovative teaching methods, facilitators significantly contribute to advancing teaching practices within educational settings.

2.4 Knowledgeable Others

In lesson study, the "knowledgeable other" plays a critical role as a facilitator and mentor, using their extensive expertise to guide educators through collaborative professional development (Lewis, 2002). They facilitate in-depth discussions, ask insightful questions, and share practices grounded in research (Lewis, 2004). Drawing on their deep knowledge of pedagogical methods or subject matter, they create a supportive environment where teachers can reflect on their teaching approaches and explore new methods (Fernandez, Cannon, & Chokshi, 2003). The knowledgeable other is essential in promoting inquiry-based learning and fostering a culture of ongoing improvement among educators (Stigler & Hiebert, 2009). Ultimately, their contributions enhance the lesson study process, improving teaching effectiveness and student learning outcomes (Hiebert & Morris, 2012).

2.5 Benefits of Lesson Study

Lesson Study offers a range of significant benefits for professional development and teaching practices. It has been described as 'an inspiring vision of teaching as a profession' (Fernandez and Yoshida 2004, p.209). Fernandez and Yoshida (2004) summarised the benefits of engaging in a LS as an opportunity to discuss content and gain better understanding of such. For teachers, LS is an opportunity to learn about how students understand and approach

content and to help teachers recognise how interesting it is to discover how children think and learn (Fernandez and Yoshida 2004). Additionally, it is found that LS greatly influences teacher's general attitudes about teaching and helps teachers see their own teaching from a realistic and grounded experience (Vrikki et al. 2017).

LS involves collaborative planning, observation, and reflection which foster a supportive environment, enhancing teacher collaboration (Lewis and Tsuchida 1998). Quaresma et al. (2018) add to the collaborative benefit of LS as they note that teacher collaboration illuminates aspects which individual teachers may not notice when working alone. The LS process also leads to a deeper comprehension of subject matter and improved pedagogical skills (Fernandez and Yoshida 2004). As teachers enhance their pedagogical knowledge and skills, they establish meaningful goals for their student's learning and their teaching (Takahashi 2005). LS is an opportunity for teachers to tailor their professional growth, focusing on specific areas of interest or improvement, resulting in PD (Fernandez and Yoshida 2004). By collectively analysing student responses, educators can adapt instructional methods to better address diverse student needs, ultimately leading to increased student engagement and improved learning outcomes (Lewis 2002). Moreover, LS encourages reflective teaching practices, influencing how teachers approach instruction in the long term (Lewis 2002). This approach fosters a culture of continuous learning and professional growth within a school cultivating a vibrant learning community (Fernandez and Yoshida 2004). Engaging in collaborative, research-based practices like LS can also elevate teacher morale and job satisfaction, leading to increased professional efficacy (Lewis and Tsuchida 1998). Furthermore, Quaresma et al. (2018) concur with many of these benefits and also note that lesson study has the ability to inform the introduction of curricular reform. Reforming education is an intricate endeavour, and implementing those reforms is even more challenging (Fullan and Miles 1992). In Ireland, there has been a continuous effort to

formally reform and update curricula at all levels of the education system. Although Ireland has recently introduced mandated changes in curriculum to drive educational policy reforms (Walsh 2016), it is not believed that the intended curriculum aligns seamlessly with what is actually put into practice (DES 2005, NCCA 2005). Researchers have emphasised the difficulties of implementing new reform strategies within the intricate teaching landscape (O’Shea and Leavy 2013). To guarantee the accomplishment of forthcoming policy goals in Ireland, it is imperative to incorporate the insights gained from past curriculum reform endeavours. PD activities must effectively prepare teachers to acquire new pedagogical practices and cultivate an understanding of the objectives and purposes behind curriculum reform (Bernardo and Mendoza 2009). It is believed that LS has the potential to serve as an effective PD activity for supporting curricular reform as it enhances teachers capacity to align new teaching practices with the goals and objectives of the reformed curriculum (Flanagan 2021).

2.4 Lesson Study Globally

Lesson study practice has been adopted and altered globally. Originating in Japan, it has rapidly disseminated across continents, particularly in Asian countries such as Singapore, Indonesia, and Malaysia, as well as finding resonance in various European nations including the United Kingdom, Germany, and the Netherlands (Lewis and Tsuchida 1998; Lewis 2002; Isoda 2010). LS is known as Collaborative Lesson Research (CLR) in the United States, has gained remarkable global traction as a dynamic method of refining teaching and learning (Elliot 2019). This surge in international adoption underscores the universal recognition of its efficacy in promoting educational excellence.

Stigler and Hiebert (1999) were pivotal in delineating six foundational principles that underlie the Japanese lesson study model. The six principles are: A clear research purpose,

Kyouzai kenkyuu, the “study of teaching materials”, A written research proposal, A live research lesson and discussion, Knowledgeable others and Sharing of results. These principles, while rooted in the Japanese context, have been successfully applied in diverse educational landscapes worldwide (Lewis and Tsuchida 1998; Lewis 2002; Isoda 2010). They advocate for a sustained and incremental approach to improvement, underscoring an unwavering focus on student learning objectives and effective teaching practices.

Additionally, these principles call for contextual adjustments and the ongoing professional development of educators, aiming to establish a self-learning system that can adapt and evolve based on experience (Stigler and Hiebert 1999). These principles encompass the delineation of a clear research purpose, the meticulous examination of teaching materials through "Kyouzai kenkyuu," the formulation of a comprehensive research proposal, the conduct of a live research lesson followed by in-depth discussions, engagement with knowledgeable peers, and the dissemination of research outcomes.

This global embrace of lesson study as a potent tool for educational enhancement speaks volumes about its adaptability and effectiveness across diverse cultural and pedagogical contexts. Its widespread adoption underscores a shared commitment to fostering excellence in teaching and learning, transcending geographical and institutional boundaries.

2.5 Lesson Study in Ireland

In 2005, the NCCA published a report highlighting the benefits of LS as a form of professional development in Japan. Since then, LS began to be incorporated into pre-service primary level in teacher mathematics education (Corcoran 2007, Leavy, Hourigan and McMahon 2010) and in some post-primary schools (Ní Shúilleabháin 2018). The global focus on mathematics education in LS is mirrored in Ireland (O’Shea and Leavy 2013). Despite the

urge for STEM education to be implemented in primary classrooms, few studies have been conducted on LS and STEM in the Irish primary context (Flanagan 2021).

In recent years, LS has gained prominence in research, policy, and practice in Ireland (Ní Shúilleabháin 2018). The current CPD model in Ireland is criticised for weakening teachers' professional goals because it is perceived as extra hours that are neither validated nor compensated. Whereas LS allows for professional judgement to be recognised, with a greater focus on innovation and reform (Quaresma et al. 2018). Researchers have identified LS as a potential solution to the existing misalignment between research and practice in the Irish education system (Kelly and Sloane 2003). It is believed that incorporating LS can provide educators with opportunities for collaboration at both county and national levels, fostering the growth of expertise within a system that values professionalism (Ní Shúilleabháin 2018). The structure of LS, allowing teachers to work together on teaching strategies, observe classroom dynamics, and evaluate student learning, supports the implementation of these changes (Ní Shúilleabháin 2018). This surge in interest reflects a broader acknowledgment of the need for more effective PD opportunities for educators.

Overall, the development of LS in Ireland reflects a concerted effort to elevate teaching practices, foster collaboration among educators, and bridge the gap between educational research and classroom application. As LS continues to gain traction, it is poised to play a pivotal role in shaping the future of PD and educational improvement in the Irish context.

2.5.1 Lesson Study Research with Practising Teachers

In Ireland, the PDST have conducted much work on LS particularly with practising teachers. The PDST Post-Primary Maths Team are using LS to support teachers in adopting various teaching methodologies, including structured problem solving in their teaching of mathematics. They note that 'Lesson Study is recognised internationally as being the most-

effective form of professional development in changing classroom practices.’ (PDST 2024). Additionally, Hourigan and Leavy (2023) have also addressed LS research with practising teachers. In this study, the researchers introduced 19 Irish primary teachers from eight urban schools to an alternative problem-solving approach using LS as the professional development model. A key finding from this study noted that ‘LS played a crucial role in promoting reported changes, serving both as a supportive professional development model... and as a catalyst, providing teachers with the opportunity to engage in a collaborative, practice-centred experience.’ (Hourigan and Leavy 2023, p.922)

2.5.2 Lesson Study in Primary Mathematics Education

As previously mentioned, LS in primary education Ireland is growing in popularity.

However, the studies that have been conducted are primarily on mathematics education.

In the Irish primary mathematics education, there has been a great focus on LS as a research tool and model of PD (Curran 2020, Leavy and Hourigan 2019, 2021, 2022). A recent study using LS as a model of PD revealed that it helped Irish primary teachers better understand how to teach mathematics, which in turn helped the students' learning, and also supported teachers in handling the demands of curricular reform and change (Curran 2020). Curran (2020) implemented cycles of LS to explore the implementation of the new primary mathematics curriculum. This study found that from the viewpoint of educators, LS was an effective means providing them with the necessary tools and resources to effectively implement the curriculum (Curran 2020). Coinciding with the five critical levels for PD evaluation (Guskey 2000), it was revealed that teachers found LS to be a valuable and enjoyable PD experience.

They reported increased knowledge for teaching the new curriculum, particularly in Place Value, and improved skills for fostering children's adaptive reasoning. Collaboration and

sharing among LS team members increased. Teachers provided inclusive learning experiences and challenging tasks for students during the research lessons. They also effectively developed students' adaptive reasoning through targeted questioning and mathematics discussions. As a result, children in the research class successfully achieved the curriculum learning outcomes (Curran 2020).

Leavy and Hourigan have conducted ten years of LS research in Irish primary classrooms (Hourigan and Leavy 2019). Their work has made a significant contribution to the body of knowledge regarding Irish LS and preservice teacher education. The authors' research has covered a wide range of topics in addition to preservice teacher education, including LS in integrated STEM education (Hourigan and Leavy 2020) and research on LS cycles focused on a variety of mathematics themes throughout primary school including early number and problem solving (Leavy and Hourigan 2018, Hourigan and Leavy 2019).

One prevalent critique of ITE on a global scale is the gap between what is taught in universities and what teachers encounter in their classrooms. This is often labelled as a 'theory to practice gap,' and is seen as a significant factor in the effectiveness of ITE programs (Tabachnick and Zeichner 1999). Hourigan and Leavy (2019) explored the effects of learning of a LS model on pre-service teachers. Participants recognised a heightened understanding of the significance of possessing profound content knowledge, particularly regarding the intricate nature of early years' mathematical concepts. Engaging in LS was seen as a catalyst for enriching multiple facets of their professional expertise and competencies. Notably, participants noted advancements in their abilities to observe and reflect, attributing these gains to their active involvement in the LS process. Moreover, participants expressed a surge in confidence regarding their capacity to proficiently teach mathematics, directly stemming from their deepened knowledge (Hourigan and Leavy 2019).

2.5.3 Lesson Study in Primary Science Education

Science education in Ireland brings to light a complex problem which undoubtedly will have a great effect on how STEM education is implemented in Ireland. Over the past ten years, scientific education has undergone transformation, with changes evident in both post primary and primary education (Smith 2014). Despite developments and changes in both post primary and primary science education, LS in science education in the Irish primary context appears not to have been undertaken.

2.5.4 Lesson Study in STEM

Published in 2016 was the report *STEM Education in the Irish School System: Report of the STEM Education Review Group*, which illustrated several recommendations for the implantation and development of STEM in the primary school setting. It is believed that teachers will need PD in STEM for the duration of their careers and a drastic change in PD for mathematics education will be vital to STEM education (MacCraith 2016). This report also maintains that the form of PD offered is due a reformation in hope of encouraging and supporting teachers with STEM education (MacCraith 2016). As previously noted, LS is widely accepted as an effective form of PD (Lewis et al., 2009, Perry and Lewis, 2011) and a tool for curricular reform (Takahashi et al., 2013, Ní Shúilleabháin 2016), which suggests the need for more LS in STEM education to be undertaken to inform and aid the implementation of STEM in Irish primary classrooms.

Recently a study looking at LS as a professional development tool has additionally seen the focus of a LS on STEM in early years education (Flanagan 2021). In terms of PD the study revealed that due to iterative and cooperative lesson study processes, teachers started to create new pedagogical practices (Flanagan 2021). Regarding STEM education, successive and

collaborative cycles resulted in teachers feeling more confident in their teaching of STEM education (Flanagan 2021). Additionally, lesson studies in STEM have been conducted with preservice teachers in Ireland (Hourigan and Leavy 2020).

Within the Irish Primary Education context, the first study has been conducted on Online Lesson Study (OLS) and suggests OLS as a promising tool in fostering collaborative learning and PD for teachers (Holden 2023). This study on OLS and STEM found that OLS has the potential to cross boundaries and allow several schools to work together, which is not easily facilitated in face-to-face LS. Furthermore, this OLS recognised the development of teacher's own STEM content knowledge as they used Zoom and Google Drive to facilitate the OLS (Holden 2023).

2.5.5 Primary Arts Education

At present, no LS research appears to have been undertaken on primary Arts education in Ireland. December 13th, 2022, saw the first meeting of the Primary Arts Development Group wherein the group discussed the strengths and challenges associated with the 1999 Arts curriculum (NCCA 2022). Since then, the group have met several times and are working to identify key issues to inform the development of a draft rationale for the Arts Education curriculum specification (NCCA 2023). A Draft Arts Curriculum Specification was published in March 2024. The draft curriculum notes three strands; Creating, Performing and Presenting and Responding and Connecting (NCCA 2024).

2.6 Conclusion

To conclude, LS is a model that has potential to deepen teacher knowledge hence impacting classroom practices (Curran 2020, Quaresma et al. 2018). In this chapter the many identified benefits showcase the potential of LS in supporting curricular reform in not only mathematics but for STEAM education. Further research is required to investigate LS as a potential form

of PD in Ireland and to explore its potential as a supporting factor in curricular reform in Ireland. This study uses LS as a vehicle to explore STEAM education in early years education.

Chapter 3: Literature Review on STEAM

3.1 Introduction

This chapter provides a comprehensive examination of the multifaceted landscape of STEAM education, encompassing its origins, integration, and impact on educational paradigms.

Beginning with an overview of STEM and STEAM, this chapter delves into the evolution of STEAM education and its integration within contemporary learning environments. The discussion extends to the context of Ireland, exploring its situation of STEAM. Subsequently, this chapter investigates the benefits associated with STEAM, emphasising its pivotal role in nurturing 21st-century skills essential for future success. Further, the exploration extends to early childhood education, elucidating the incorporation of STEAM principles and its alignment with the Aistear framework. Finally, this chapter underscores the pivotal role of educators in facilitating effective STEAM instruction, emphasising their training, support, and the challenges they may encounter in promoting STEAM-driven learning experiences. Through a comprehensive examination of these key aspects, this literature review aims to provide a robust foundation for the ensuing discussions on STEAM education.

3.2 STEM Overview

Whilst it may appear that STEM is a recent global topic, the acronym dates to the 1990s in the United States of America (English 2016). However, in recent years, STEM education has become a highly discussed topic in international educational and policy agendas. It is regarded as essential to the economy, global competitiveness, and eventually future progression on a national and individual level (Flanagan 2021). As it is vital in ensuring economic prosperity, it is of high importance to governments around the world (Bell 2016, Brown 2012).

At present, STEM is an international topic of discussion driven by the challenges of a changing global economy and fuelled by future predictions (Bell 2016). If the predictions and calculations based on current and past STEM careers uptake and student's current attitude towards STEM become true, a global issue will arise with an insufficient number of people equipped or willing to follow STEM careers (Bell 2016). With pressure rising some believe 'STEM learning is no longer a luxury but a necessity' (McClure et al. 2017, p.10).

Despite there being a compelling economic case for introducing STEM education as nations strive to be globally competitive, the National Research Council (NRC) (2011) notes that the significance of early STEM education has a much broader rationale and compelling agenda. STEM education should not be just for those who intend on going to college or pursuing professions in the field as all children who engage with STEM education will be more equipped to handle the opportunities and problems of a society that is dominated by STEM disciplines (NRC 2011). Children can be empowered through STEM by enhancing their scientific literacy and understanding of the world, which will help them become more informed citizens who can compete in the global economy (Huling & Speake Dwyer, 2018). As STEM literacy is necessary for addressing environmental challenges, social issues, personal decision-making, and cultural advancement, increasing STEM literacy among all students is an important goal (Murphy et al., 2023, Huling & Speake Dwyer, 2018).

It is believed that STEM naturally develops the four Cs of 21st -century skills: critical thinking, communication, collaboration, and creativity (Bybee 2013). An all-encompassing framework for producing citizens capable of tackling 21st-century challenges is provided by STEM and the four Cs (Bybee 2013).

3.3 STEM Education in Ireland

The STEM Education in the Irish School System report was published in 2016, driven by global discussion on the importance of STEM, and the desire for Ireland to be a ‘hub of technological creativity and an innovation leader’ (STEM Education Review Group (STEMERG) 2016, p.7). The report recognises both strengths and weaknesses of the current STEM landscape in Ireland, ranging from the highly active informal STEM education sector eg. BT Young Scientist and Technology Exhibition (BTYSTE), SciFest, CoderDojo, to

significant gender imbalance in the selection of science subjects at Leaving Cert level (STEMERG 2016).

The STEM landscape in Ireland

STEM Curricula in the Irish Education System

Sector	Area	Subject
	Science	Science
Primary	Technology	Although not a curriculum subject per se, the use of ICT, as a means of enhancing teaching and learning, is promoted across the primary school curriculum
	Mathematics	Mathematics

Figure 4: STEM Landscape in Ireland (STEMERG 2016, p.14)

Notably, Innovation 2020 does not address the lack of a national STEM policy or plan nor does it push for its establishment despite recognising the necessity for a high-performing STEM Education system in Ireland (STEMERG 2016). STEM Education Implementation Plan to 2026, published in 2017, states;

‘Ireland will be internationally recognised as providing the highest quality STEM education experience for learners that nurtures curiosity, inquiry, problem-solving, creativity, ethical behaviour, confidence, and persistence, along with the excitement of collaborative innovation.’

(DES 2017, p.4)

In hopes of achieving such a goal, the DES outlines four pillars. The plan is aimed at early childhood, primary and post primary education (DES 2017).

- Pillar 1.** Nurture learner engagement and participation
- Pillar 2.** Enhance early years educator and teacher skills
- Pillar 3.** Support STEM education practice
- Pillar 4.** Use evidence to support STEM education

Figure 5: Four Pillars (DES 2017, p.5)

In March 2023 the STEM Education Policy Focus Group Consultation Report was published. The conversations behind this report revealed a continued necessity to provide a more detailed definition of STEM education in both early years and primary settings (DES 2023). Educators in ECE are eager for concrete illustrations of how they can implement STEM education (DES 2023). Meanwhile, primary teachers are in search of guidance on how it aligns with the existing curriculum (DES 2023). Additionally, they express a need for PD in understanding integrated STEM practices at the primary level (DES 2023).

In March 2024, a new draft specification for STE education was released. This draft specification aims to enhance learning through integration of these disciplines. An emphasis is placed on adopting an interdisciplinary approach, linking scientific inquiry with technological and engineering processes (NCCA 2024). It encourages students to participate in problem solving exercises that foster innovation, analytical thinking and teamwork. Curious Disposition, Skills Development, Conceptual and Procedural Understanding, Creative Innovation, Critical Engagement and Communication and the use of Disciplinary Language are noted as the key aims of STE education (NCCA 2024). Despite its name ‘STE education’, STEM is mentioned across the specification. Notably, STEAM is absent from this documentation.

3.4 From STEM to STEAM

In 2006, Georgette Yakman, drawing on her varied academic and professional background, including expertise in clothing, technology, and STEM education, saw the value in blending creative and innovative concepts from the arts into STEM education (Leavy et al. 2023).

Yakman introduced the term STEAM, emphasising an integrated curriculum approach (Yakman 2008; Yakman & Lee 2012). Since then, there has been a rising global interest in STEAM teaching methods among educational experts, practitioners, and decision-makers (Leavy et al. 2023).

STEM education is now often accompanied by the addition of the Arts discipline to make STEAM education (Aguilera and Ortiz-Revilla 2021). Both educational strategies aim to improve students' STEM literacy and 21st century skills, and with the addition of the arts, student creativity appears as a crucial competency (Aguilera and Ortiz-Revilla 2021).

It is often acknowledged that the addition of the Arts into STEM curricula allows children to express STEM concepts with more ease (Sharapan 2012). These researchers suggest that the addition of the Arts allows children to express ideas about the world through music, dance, or illustration (Daugherty 2013, Sharapan 2012). However, others argue that if the Arts are included, the Arts should also be taught (Leavy et al. 2023).

At present, with the exception of a handful of studies (Liston, Morrin, Furlong & Griffin, 2022) there is little literature available on STEAM in Irish primary schools. This study highlights that merging STEAM into education requires time, teamwork from various parties, ongoing backing, extensive high-quality training, resources, and most importantly, dedication from educators and school communities (Liston et al. 2022). An international study has found that both STEM and STEAM develop creativity in children, and they argue choosing

STEAM over STEM is an ‘invalid argument’ (Aguilera and Ortiz-Revilla 2021, p.11). Studies in the United States argue that despite a focus on STEM and STEM disciplines in recent years, there are still fewer students following STEM careers as they ‘are not ready for the 21st Century workforce because they lack innovation and creativity’ (Rice 2020, p.2). STEAM advocates argue that the arts be reintroduced into classrooms in order to include students in learning that is meaningful and establish a link between creativity and reason (Rice 2020).

3.5 STEAM Education Overview

There are different views on the purpose of STEAM education. Most empirical studies follow two main approaches (Leavy et al. 2023). The first sees the Arts as tools for improving learning in STEM subjects (Ge et al. 2015). On the other hand, the second approach highlights the need to develop students' broader skills like creative thinking, problem-solving, and the ability to apply knowledge across different areas (Perignat & Katz-Buonincontro 2019). Ge et al. (2015) also mention a less common third approach, which sees STEAM as a way to bolster arts education.

In order to include the fifth field, the arts, to STEM, Korea's Ministry of Education, Science, and Technology (MEST) developed a STEAM paradigm in 2011 (Flanagan 2021). The concept of STEAM was shortly after recognised in the US in 2012 when the NRC recognised a shortage in the uptake of STEM careers (Alghamdi 2023). Based on research showing that creativity benefited science instruction, STEM was expanded to incorporate the Arts and has become STEAM (Ozkan and Umdu Topsakal 2021). Introducing an aesthetic viewpoint on daily life, STEAM takes a different approach to STEM and incorporates computer graphics, performing arts, creative planning, and even playful problem solving (Ozkan and Umdu Topsakal 2021). However, while many STEM lessons naturally incorporate the Arts, a key

aspect of STEM education is to improve mathematics and science skills in children and researchers wonder will the inclusion of the Arts alter the goal of STEM (Jolly 2014)?

While STEM is regarded as rational and practical, art is regarded as perceptive and emotive, and it has given STEM a new source of motivation by enhancing creativity and problem solving skills (Sousa and Pilecki 2013). The learning experiences of both creative and logical-mathematical thinkers can be bridged by integrating disciplines like art with more conventional disciplines like mathematics and science (Alghamdi 2023). Several benefits have been associated with the addition of Arts such as to stimulate cognitive development, enhance long-term memory, foster creativity, facilitate social development, and lessen stress (Sousa and Pilecki 2013). Through playful, hands-on activities, art is a natural way for young children to develop their creative production and innovative building skills (Alghamdi 2023).

Notably much of the literature discussed in the sections to follow is in relation to STEM, this is primary due to the paucity of research in STEAM. Research in STEAM is being carried out; however, the publication of efficacious research is still in its infancy (see Leavy et al., 2021). However, it is envisioned that the many of the features and challenges that are present in the STEM education literature would be shared by STEAM education, due to the underpinning role of multidisciplinary contexts.

3.6 STEAM Integration

Researcher's outline and highlight how integrated STEM instruction supports student's understanding and addresses the idea that real world problems are rarely if ever isolated within one discipline of knowledge (Breiner et al., 2012). While it is agreed that the disciplines "cannot and should not be taught in isolation, just as they do not exist in isolation in the real world or the workforce" (STEM Task Force Report 2014, p.11). Much literature

and research highlight a prevailing challenge or uncertainty around STEM Education as different perspectives are held on what STEM Education and integration should look like (Colucci-Gray et al., 2017; English 2016; Liston 2018; Quigley and Herro 2016).

English (2016) provides a basic understanding of integration as working in context on complex problems that require students to draw upon knowledge and skills from many disciplines. Whereas Vasquez et al.'s (2013) suggests a more thorough vision of integrated STEM, where a range of boundary-crossing behaviours are shown along a scale with increasing levels of integration, with advancement along the scale implying a greater interconnectedness and interdependence across the disciplines.

Three primary methods exist for teaching and learning STEAM. STEM researchers suggest that integration can be achieved in several ways; multidisciplinary, interdisciplinary, and transdisciplinary (English 2016). The first, termed multidisciplinary, entails instructing fundamental concepts and skills individually before integrating them through a shared theme. The second, known as interdisciplinary, involves teaching closely related concepts and skills from multiple disciplines concurrently to foster deeper understanding and proficiency. Lastly, the transdisciplinary approach applies knowledge and skills from various disciplines to address real-world problems, aiming for a comprehensive learning experience that addresses complex, practical challenges (English, 2016). An interdisciplinary approach to the teaching STEM is favoured by many (English 2016, Gomez and Albrecht 2013). Additionally, a fourth type of disciplinary integration surfaced; Cross-disciplinary. Cross-disciplinary STEAM education involves examining one field through the lens of another, such as exploring the physics of music (Gates 2017). Whilst these studies are based upon STEM, the researcher has applied the knowledge to STEAM for the purpose of this study.

Undoubtedly the optimal approach and implementation of STEM education would be that of integrating all disciplines simultaneously, however in reality, such is not possible in the current structure of education (Ozkan and Umdu Topsakal 2021). It is assumed the same knowledge should apply for STEAM. A systematic review of the literature exploring the prevalence of integrated STEAM and emerging technologies suggested that meaningful integration across all disciplinary domains rarely happened (Leavy et al., 2023). As such a level of integration appears difficult to achieve, a more practical approach sees that of integrating two or more disciplines at a time (Sanders 2008).

Other researchers claim there are two different forms of STEM integration: content integration or context integration (Moore et al. 2014). Context integration involves applying various STEM settings to make information more relevant, whereas content integration refers to mixing various STEM fields in a single activity (Moore et al. 2014).

Making integrated STEM connections is challenging, and teachers must teach STEM material purposefully to ensure that students understand how to apply STEM knowledge to real-world issues (Kelley & Knowles, 2016). Well-integrated instruction gives students the chance to learn in more engaging situations, promotes the use of higher order critical thinking abilities, enhances problem-solving abilities, and improves retention (Stohlmann et al. 2012).

However, despite recent requests for such an approach to be taken, notably in those of mathematics and science, teachers themselves are not trained to teach by depending on the integration of many disciplines; as a result, often they are or feel ill-equipped to apply a cross-disciplinary approach in their teaching (NGSS 2013).

To conclude, the incorporation of STEM disciplines gives students the chance to tackle realworld problems in situations that are reminiscent of the real world (Tsupros, Kohler & Hallinen, 2009), where knowledge is applied as a tool to address issues rather than as a body of facts or procedures to be memorised without much context (Herschbach, 2011). Researchers seek more focus on STEM integration and a more equitable representation of the disciplines (Cunningham 2018, English 2016).

3.7 What should STEAM Education look like?

At present a lack of understanding and certainty prevails regarding the design of STEAM education (Colucci-Gray et al., 2017; Liston 2018; Quigley and Herro 2016). It is agreed that STEAM education is seen as an attempt to create purposeful learning environments, moving away from acquiring facts to investigating and implementing principles and theories wherein students gain understanding through application and therefore become more STEM literate (Bell 2016), yet how this is achieved is yet to be determined. Some academics interpret the term "Arts" as pertaining solely to visual art, while others use 'Arts Education' to encompass a range of arts like visual, performing, digital media, aesthetics, and crafts (Herro & Quigley, 2016a; Quigley et al., 2017).

Huling and Speake Dwyer (2018) outline attributes of STEM classrooms and lessons. Firstly, STEM classrooms and lessons prioritise an active and student-centred approach. These environments are equipped to facilitate both planned investigations and spur-of-the-moment inquiries, encouraging curiosity and exploration. Moreover, they serve as hubs for innovation and invention, fostering a culture of creativity. In STEM settings, the boundaries between traditional classroom, laboratory, and engineering lab blur, creating a seamless space for hands-on learning. These spaces are thoughtfully designed to support diverse learning styles

and accommodate students with varying abilities or disabilities. Additionally, STEAM education integrates real-world situations or problems, providing students with authentic, applicable contexts for their learning (Huling & Speake Dwyer, 2018)

Clements and Sarama (2016) believe STEM should follow a research-based trajectory encompassing three components: a goal, developmental progression and instructional activities. They state that learning progresses along research-based trajectories not in developmentally appropriate classrooms.

However, Resnick (2017) sees kindergarten as the optimal approach to developing 21st century skills not just in children but everyone, as kindergarten style learning works to enhance creative capacities in people. The Creative Learning Spiral (CLS) requires one to imagine, create, play, share then reflect, and is repeated again and again with varying materials but the same process (Resnick 2017). ‘The Creative Learning Spiral is the engine of creativity’ (Resnick 2017. p.12). As children go through the spiral they hone and improve their capacity for original thought by experimenting with their own ideas, testing them out, seeking inspiration from others, and coming up with new ones based on their experience.

Tanna (2016) concurs with elements of CLS yet illustrates the importance of context-based learning in STEM education. This study focused on the use of fairy tales for context and found that girls and students in urban schools who come from more racially and economically diverse backgrounds benefited the most from storytelling's ability to help children learn, retain, and transfer geometric concepts (Tanna 2016). Similarly, Jeon et al. (2016) explored the fusion of robotics with theatre, effectively incorporating coding into the realm of arts. In all these studies, the objectives for STEAM learning revolved around the application of

technology, coding, and the arts. Such findings highlight the importance of contextualisation to ensure the inclusion of and optimal learning for all in STEM education.

A recurring theme in literature is the importance and positive effect of the collaborative aspect in STEM tasks (Cunningham 2018, Resnick 2017, Tanna 2016). Working collaboratively is not only a 21st century skill but in a study done on literature to help students learn STEM skills, it was discovered that this aspect was vital to its success as it supported students in experiencing failure and allowed them to adjust their work without feeling insecure (Tanna 2016).

At present, much teaching in primary schools across all disciplines remains heavily on delivering instruction rather than supporting the creative process (Resnick 2018). While it is believed students ought to be supported in the understanding of core concepts, the opportunity should be there for them then to apply such knowledge as they wish in problem solving tasks (Cunningham 2018, English 2016). Teachers can offer STEAM conversations by simply talking out loud about things they notice in the world (Sharapan 2012), which has the potential to lead to projects or activities that are open-ended and of interest to students (Cunningham 2018).

3.8 Benefits of STEAM Education

There is a growing body of research suggesting that inclusion of the arts has good outcomes for many aspects of learning. It has aided interest in STEM and increased motivation and interest in STEM disciplines (Bevan 2017, Henriksen 2014, Land 2013).

A number of research findings demonstrated a significant drive to advance fairness and enable inclusive participation of all students in STEAM education (Callahan 2019; Champion 2018; Kaneko and Yamada 2019; Kant, Burckhard, and Meyers 2018;) In Callahan's (2019) study, fashion design and aesthetics were integrated to create personally meaningful learning experiences, especially for females, particularly those belonging to underrepresented ethnic groups. Likewise, Champion (2018) utilised makerspaces within a dance studio as a means for minority females to convey themselves through coding, incorporating smart sensors into their choreography. Additionally, Kaneko and Yamada (2019) have made efforts to incorporate students from disadvantaged backgrounds, including those from low-income families, rural areas, and children with disabilities.

STEAM enthusiast Ruth Catchen views the incorporation of the arts as a "ramp" for kids from underrepresented groups and believes that they are an essential teaching tool (Jolly 2014). Students' motivation is increased and their likelihood of succeeding in STEM is increased when art activities are used to play to their strengths (Jolly 2014). It is believed that using art may increase everyone's access to STEM fields and provide more varied educational opportunities (Jolly 2014). Similarly, an Irish STEAM study, found that integrating the arts introduced an emotional element to intricate STEM concepts and challenges, rendering them more approachable and captivating (Morrin and Liston 2020). The teachers from this study noted that the interactive teaching methods captivated and inspired all students (Morrin and Liston 2020).

Articles frequently mention creative thinking, innovative problem-solving, the cultivation of creative abilities, or creativity as a result of engaging in STEAM (Choi and Behm-Morawitz 2017; Grinnell and Angal 2016; Keane and Keane 2016). This notion of creativity is closely

associated with the arts and is described as a notable advantage or educational achievement derived from STEAM education (Perignat and Katz-Buonincontro 2019).

STEAM Education merges the arts with the STEM disciplines to develop 21st century skills (Liao 2016; NAEA 2016; Perignat and Katz-Buonincontro 2019). Feedback from children made it clear that engaging in the STEAM Ed project enhanced their abilities in observation and problem-solving (Morrin and Liston 2020). Furthermore, STEAM education offers students the opportunity to develop analytical abilities to create complex systems and solutions, but also requires creative skills to implement them effectively (Land 2013).

Combining arts and sciences results in a unique skill set that improves the transition from concepts to practical applications (Land 2013). This integration allows students to both break down complex problems and apply solutions in real-world situations (Land 2013). Including arts in STEM education gives students the opportunity to find personal meaning and motivation, enabling them to take charge of their own learning.

3.9 21st Century Skills

In the 21st century, the landscape of education has evolved to encompass a set of skills essential for success in an increasingly complex and dynamic world. These skills, commonly referred to as 21st century skills, encompass a diverse range of abilities that go beyond traditional academic knowledge (Partnership for 21st Century Learning, 2007). Developing 21st century skills in children is a key goal and a natural development of STEAM education (Gravemeijer et al. 2017).

Trilling and Fadel (2009) categorise what they believe the key 21st century skills children need to develop into three categories: learning and innovation skills, digital literacy skills and

career and life skills. However, various models for 21st-century skills have been introduced (Binkley et al. 2012; P21 2009). Many of these share similarities with concepts like lifelong learning competencies (OECD 2018). Although these frameworks categorise the recommended competencies differently, there is significant common ground among them including ‘critical thinking, creativity, problem solving, decision making, ICT and information literacy, communication, collaboration, citizenship, personal and social responsibility, and life and career skills’ (Bergsten and Frejd 2019, p.943)

How can we develop these skills? There is no definitive answer to this question however researchers suggest engaging children in high levels of challenge, especially from personal interest, high levels of external caring and personal support from teachers and being allowed the opportunity to fail (Claymier 2014, Trilling and Fadel 2009). As the world of work is witnessing more and more teams of people working together, such should be similarly seen in classrooms with students working together to solve problems or challenges and incorporating technology into student’s learning (Bell 2010). Seeing as the world is full of real-world challenges, problems and questions, teachers should aim to engage students in such (Lindeman and Anderson 2015, Trilling and Fadel 2009).

Numerous research endeavours have been aimed at cultivating 21st-century competencies, including traits like persistence, creativity, and problem solving, through involvement in STEAM education (Leavy et al. 2023). Stelck's (2018) exploration focused on elementary students' acquisition of persistence, differentiating between macro-persistence and micropersistence. The findings underscored the significance of student autonomy in choosing specific STEAM undertakings, as well as the medium of materials employed in augmenting levels of persistence. Engelman et al.'s (2017) study using Earsketch, illustrated a connection

between an authentic and innovative STEAM learning environment and a range of psychosocial factors commonly employed to forecast persistence in computing. Similarly, Oh et al.'s (2013) study revealed that the implementation of a STEAM program that incorporates Scratch led to enhanced levels of creativity. Moreover, the use of technology and digital tools in STEAM education nurtures digital literacy, a crucial component of 21st century skills (International Society for Technology in Education 2016).

3.10 STEAM Education in Ireland

3.10.1 Primary Science Ireland

Science was first introduced into the primary curriculum in 1971, alongside geography and the subject was referred to as social and environmental studies. Following this came the introduction of the 1999 curriculum wherein science was paired with history and geography, under social, environmental and scientific education (SESE). The primary school curriculum (PSC) welcomed reform to primary science education, with a focus now on engaging the children in a child centred, inquiry-based learning approach (Varley et al. 2013). However, subsequent to research conducted by Varley et al. (2008) on behalf of the NCCA, it was discovered that there are several issues with the implementation of the science curriculum. Children reported didactic methods, showed little development in skills as they got older, and lacked higher order thinking skills (Varley et. al 2008).

Undoubtedly, such findings are linked with the research stating how many Irish primary teachers are hindered in their confidence and competence because they lack adequate content and pedagogical knowledge of science (Murphy and Smith 2012, STEMERG 2016). As at present it is evident the goals of the current primary science curriculum are struggling to be

met, there is no doubt that the implementation of STEM or STEAM education is going to be a challenge (Shiel 2018).

The new primary curriculum framework situates science under STEM education (NCCA 2023). In this framework it is stated that science, technology, and engineering are closely connected fields that provide children with the opportunity to explore and engage with various types of technologies, both old and new (NCCA 2023).

3.10.2 Technology in the Irish Primary Educational Context

Acknowledging the vast developments in Information and Communications Technology (ICT) since the development of the 1999 curriculum, in 2004 the NCCA introduced ‘Information and Communications Technology (ICT) in the Primary School Curriculum: Guidelines for Teachers’. In recent years, the Department of Education and Science have shown their support for the use of ICT in the classroom by increasing availability of ICT in schools and ICT PD opportunities for teachers (NCCA 2004).

‘Technological skills are increasingly important for advancement in education, work, and leisure. The curriculum integrates ICT into the teaching and learning process and provides children with opportunities to use modern technology to enhance their learning in all subjects.’

(PSC 1999, p.29)

The term ICT includes computers, computer networking, multimedia, and assistive technologies (AT), and aims to enhance learning across all curricular areas (NCCA 2004). However, researchers note that it is vital to remember that technology did not begin in the digital age (Moomaw 2013), ‘Technology is just a fancy word for tools’ (Sharapan 2012,

p.57). Inventors have been inventing tools such as simple devices we use each day for millennia and may be given curriculum application of technology in the classroom (Moomaw 2013). Additionally, nowadays coding is becoming increasingly important globally and therefore in the primary school classroom (Lloyd and Chandra 2020). Due to the newness of teaching coding and computational thinking, undoubtedly time and support are needed to consolidate learning for teachers (Lloyd and Chandra 2020).

Furthermore, the new Digital Strategy for Schools 2015-2020 was launched in 2015, addressing new digital technologies and a clear vision for use in schools to enhance teaching, learning and assessment (STEMERG 2016). Again, this plan reiterates the need for preservice training in ITE, and PD for current teachers (DEIS 2015). Recent reports regarding ITE standards state that by the end of the programme of ITE, the student teacher will be able to ‘employ relevant technical knowledge and skills of a range of digital technologies including multi-media resources, effectively to facilitate teaching and assessment practices’ (The Teaching Council 2020, p.25).

3.10.3 Engineering in the Irish Primary Educational Context

Many researchers believe that for a lesson to be considered STEM or STEAM, engineering must be a key aspect (Jolly 2017, Liston 2018). ‘Engineering has to take centre stage during STEM activities. Engineering is the glue that integrates science, mathematics, and technology’ (Liston 2018, p.36). Others agree and claim that ‘STEM lessons are engineering lessons that integrate math and science.’ (Jolly 2017, p.69).

The Engineering Design Process (EDP) is made up of eight steps and students are guided by the model embedded in the EDP from problem identification to solution development (Liston 2018).

Steps to the Engineering Design Process (EDP)

1. Defining the problem: introducing criteria and constraints
2. Conducting research: look up videos, images, architecture etc.
3. Imagining: brainstorming informed ideas on how to solve the problem posed and come up with a number of possible solutions and ideas
4. Planning: Choose the idea that the group predicts will work best and design their prototype. This involves sketching out their design.
5. Creating: designing and developing the prototype they have all selected.
6. Testing and evaluating the prototype
7. Redesigning based on the testing and evaluation stage if required.
8. Communicating and presenting their results and conclusions.

Figure 6: Steps to the Engineering Design Process (Liston 2018, p.36)

Whilst for some it may be confusing on how to include engineering in early years education, others believe that young children have an inherent talent for engineering that can be often overlooked or missed (McClure 2017). Children's play often requires them to build, test, change and discuss yet the complex inner processes in the minds of children when doing so is difficult to observe hence resulting in adults underestimating the abilities of these children (McClure 2017)

Problem solving is intrinsically linked to engineering, yet solving any real-world problem draws upon multiple disciplines (Cunningham 2018). Despite such findings, it is vital to highlight that the Draft Curriculum Framework (NCCA 2020) did not mention engineering nor STEM which suggested that the next primary curriculum was intended to be implemented without the inclusion of STEM education (Flanagan 2021). However, the recent publication of the Draft Science, Technology and Engineering Specification proves otherwise. This draft curriculum is the first time Engineering has been included in Irish Primary Curriculum.

3.10.4 Primary Arts Ireland

Presently, the primary arts curriculum consists of visual arts, drama, and music. The curriculum enables children to explore and express ideas, feelings and experiences through music, drama, and the visual arts. Earlier this year, a new primary curriculum framework was released with drama, art and music falling under Arts Education (NCCA 2023). At present, the Primary Arts Development Group is currently working to identify strengths and challenges of the current primary arts curriculum to inform the arts education curriculum specification (NCCA 2023). It is envisaged that a new specification for Primary Arts Education will be finalised in early 2025 (NCCA 2023). Research is currently being conducted by Marino Institute of Education on behalf of NCCA to develop the research base for this curriculum area. March 2024 saw the publication of a Draft Arts Education Curriculum Specification. The draft curriculum notes the importance of meaningful and child centred learning to engage the children in the interrelated processes of the three strands (NCCA 2024).

3.10.5 Primary Mathematics Ireland

In September 2023 the new Primary Mathematics Curriculum was released with implementation scheduled for September 2024. In the primary curriculum, Mathematics is situated within the STEM Education curriculum area. Similar to that of the 1999 science curriculum, reviews, evaluations and research on the previous 1999 mathematics curriculum presented challenges and indicated the need for a new primary mathematics curriculum (NCCA 2018, STEMERG 2016).

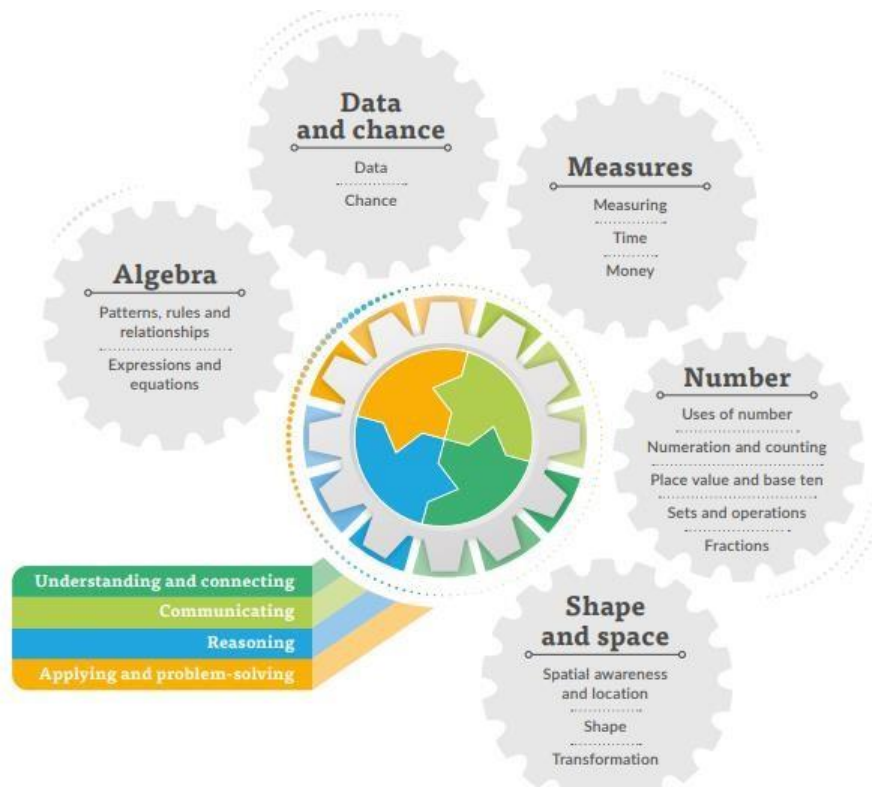


Figure 7: Strands and Elements (NCCA 2023, p.14)

After much speculation, particularly regarding the younger classes, the NCCA confirmed the new mathematics curriculum was contribute in developing the foundations of coding in the younger classes by giving students the chance to ‘to develop computational, flexible and creative thinking skills’ across the strands (NCCA 2018, p.13). Following the release of the new Primary Mathematics Curriculum (2023), it is evident that coding is not included.

However, coding is to be included in the broader STEM curriculum which is currently under construction by the STEM Development Group (NCCA 2023).

Stemming from the Report on the consultation with children on the Draft Primary

Mathematics Curriculum (2023), it became evident that children enjoyed and wished for their experience in mathematics education to consist of a variety of pedagogies, more playful approaches, the opportunity to work collaboratively and share strategies with each other (Leavy et al. 2023). The study also found that ‘the practices valued by the children mirror advocated best practices in the teaching and learning of mathematics’ (Leavy et al. 2023, p.78). The report also stated that ‘context-rich problem-solving experiences... linking mathematics with the outside world’ were several children's favourite mathematical memories (Leavy et al. 2023, p.79). Context-rich problem solving and real-world problem solving, link closely with proposed STEM or STEAM education methods (Liston 2018).

3.10.6 The Primary Curriculum Framework

As previously referred to above in the different curricular areas, 2023 saw the introduction of a new primary curriculum framework. The core of the primary curriculum comprises seven essential skills that complement and reinforce the curriculum's overall vision. These competencies, as delineated in the Primary Curriculum Framework, expand upon the abilities children develop during their early education with Aistear: The Early Childhood Curriculum Framework. These skills are further reinforced during post-primary education in the Junior Cycle.

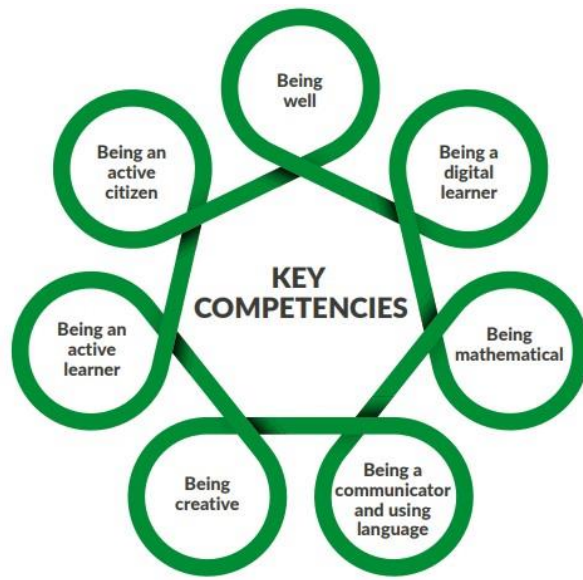


Figure 8: Primary Curriculum Framework Key Competencies (NCCA 2023, p.5)

The key competencies noted in this new curriculum framework link closely to the nature of STEAM.

3.11 Early Childhood Education Ireland

Early Childhood Education (ECE) in Ireland is guided by Aistear (2009), a curriculum framework for children from birth to six years (NCCA 2009). The framework showcases learning and development through the four interconnected themes of Well-being, Identity and Belonging, Communicating, and Exploring and Thinking (NCCA 2009). Accompanying guidelines focus on different pedagogies in supporting teachers enhance children’s learning and development across the four themes. The current guidelines emphasize building strong partnerships between parents and practitioners, fostering learning and development through meaningful interactions and play, as well as providing robust support for learning and development through effective assessment practices (NCCA 2009)

Similar to much ongoing primary curriculum development, an Updating Aistear

Development Group was formed with hopes of an updated Aistear envisaged in 2024 (NCCA 2023). Interestingly, this is noted to not be a major review as recent reports find the themes continue to illustrate children's development and learning appropriately (NCCA 2021, O'Donnell 2018).

3.12 STEAM in Early Childhood Education

'Today's preschoolers are tomorrow's inventors and problem solvers.' (McClure et al. 2017, p.10). Learning STEM should be considered a relevant and significant educational objective based on children's fundamental abilities and innate interests (Clements and Sarama 2016). Children naturally develop the foundations of STEM (Clements and Sarama 2016, Cunningham 2018, McClure et al. 2017, Sharapan 2012), hence building on this through STEM curricula seems obvious. Children demonstrate this natural ability and readiness through their play such as building dens, towers, water play etc. (McClure et al. 2017). A recent Irish study found a general consensus that play and STEM naturally align (Flanagan 2021). Clements and Sarama (2016) add that the simple 'why' questions that young children ask to illustrate that STEM is natural and interesting to them.

Research shows that despite current findings, many believe that 'real' learning across the STEM disciplines doesn't happen until they are older and that implementing STEM activities in early childhood education will be beneficial for 'laying a foundation' for this later learning (Clements and Sarama 2016, McClure 2017). This is contested in research. According to research, young children can engage in scientific processes that older students do, at levels that are developmentally appropriate (McClure et al. 2017).

Nowadays, children are born and raised in a world nursing with technologies (Sung et al. 2023). To meet the needs and developments of society,

“children must learn how to proactively analyse and solve problems using the 4Cs (creativity, critical thinking, communication, and collaboration) and 3Rs (reading, writing, and arithmetic) as future competencies.”

(Sung et al. 2023, p,1)

The Early Childhood STEM Working Group (2017) reports that high quality STEM education fosters children's capacities, attitudes, and behaviours to flourish in STEM fields. Due to worries that such a focus on the STEM disciplines might disrupt playful, creative pedagogies vital in early years education, it is believed that STEAM education is ‘highly suitable’ as children are naturally inclined towards the Arts (Clements and Sarama 2016, Sung et al. 2023, p.2). Literature states as the Arts are a natural part of ECE, the addition of this discipline to STEM will undoubtedly be of benefit to both students and teachers in addressing STEAM concepts (Sharapan 2012).

The requirement for children to have numerous and varied opportunities for STEM exploration and discovery is acknowledged in STEM education. Early childhood educators and teachers need expertise in STEM fields, pedagogical content expertise, the necessary abilities, and confidence (DEIS 2017). It is necessary to increase preparation, development, and support through initial early years educator preparation, induction, and CPD (DEIS 2017, STEMERG 2016).

3.12.1 Aistear and STEAM Education

The NCCA (2018) notes how the draft PMC builds upon the principles of Aistear, the Early Childhood Curriculum Framework (NCCA, 2009), as should STEM or STEAM education. These key principles emphasise the value of relationships between adults and children as well as fun and fulfilling activities for kids' growth and learning (NCCA 2009). Notably, the

principles and pedagogies mentioned in new Primary Mathematics Curriculum (2023), utilise the ‘stem’ ‘Through appropriately playful and engaging learning experiences’ when introducing the learning outcomes (NCCA 2023, p.18). Embracing a playful and captivating method to education aims to portray Mathematics as an inclusive and approachable realm of learning. Additionally, it encourages children to recognise the elegance, complexity, and influence of Mathematics (NCCA 2023). As seen in figure 9, ‘Encouraging Playfulness’ is one of the five key pedagogical practices for the classroom (NCCA 2023).

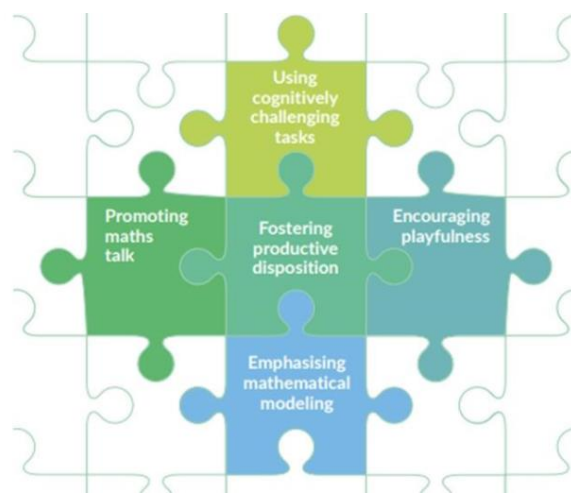


Figure 9: Five key pedagogical practices for the classroom (NCCA 2023, p.26)

The new Primary Mathematics Curriculum (2023) states that ‘Encouraging playfulness’, is of benefit to all children at all stages of primary and special education as the NCCA maintain that play is central to their learning. An interactive, engaging, and inclusive play environment greatly enhances mathematical learning, encouraging exploration, creativity, and independence whilst also promoting discussions about mathematics and allowing children to make choices about their learning, strengthening their mathematical understanding and skills (NCCA 2023).

A recent Irish study on STEM in infant education found the use of play based learning highly effective regarding STEM learning (Flanagan 2021). Additionally, Aistear was credited as highly effective in supporting STEM, especially in promoting targeted language development and positive learning dispositions (Flanagan 2021). The findings from this study concur with international research stating that children develop 21st century skills through play, play and STEM align naturally, and the importance of early STEM exposure to build positive dispositions (Clements and Sarama 2016, Cunningham 2018, McClure et al. 2017, Sharapan 2012).

3.13 Teachers and STEAM Education

As STEAM education does not formally maintain a place in the Irish education system at present, many teachers lack knowledge and understanding on teaching such (DES 2023). While some may only briefly know the term and others have great interest in the area, this large gap in knowledge and understanding firstly on what STEAM is, and secondly how STEAM education can and should be implemented effectively, remains (DES 2023). Hence a recurring theme in much recent research on teacher's perspectives, understanding and knowledge on STEAM education and its implementation is the need for professional development in the area (DES 2023; Leavy et. al 2023).

With the already busy workload, it is no surprise that teacher's struggle to take time to learn about and implement new reform-based teaching strategies (Brown and Bogiages 2019). However, despite research findings illustrating that teachers lack knowledge on how to implement STEM or STEAM education, often it may be the case that teachers are already providing such education unknowns to themselves (Sharapan 2012). Teacher's need and

many desire extensive training and professional development to actively engage their students in developmentally appropriate STEAM learning (McClure et al. 2017).

However, whilst many are eager to learn about STEAM education, research regarding STEAM education implementation highlights and reinforces the need for highly qualified teachers (Bell 2016). As studies show teachers' perceptions of STEM, as well as their own knowledge and comprehension of the disciplines, are directly related to how well STEM instruction is delivered in their own classroom settings (Bell 2016, STEMERG 2016).

Teachers who lack knowledge and confidence in the disciplines themselves, struggle to teach it or do not have a positive outlook on it which in turn will be passed to their students (STEMERG 2016). Sharapan (2012) suggests teachers should try to see STEAM concepts through children's eyes, more so everyday language than intimidating academic concepts.

To conclude, the prevailing uncertainty regarding STEAM education perspectives, knowledge and understanding, illustrates a clear need for high quality CPD, teaching and learning materials and resources (Liston 2018). As for the most part the problem is not that teachers and parents lack enthusiasm around such but more so knowledge and support (McClure et al. 2017). Noted by STEMERG (2016), STEM teacher education must be treated as a key priority to achieve high quality STEM education in Irish schools. STEAM education is in the same position.

3.14 Conclusion

STEAM education is a widely discussed topic globally due to growing concerns of a changing global economy (Leavy et al. 2023). This chapter initially explored the current STEM and STEAM landscapes, prior to examining the disciplines in the Irish educational context, to highlight Ireland's current STEM landscape. Several changes and developments currently ongoing in Ireland regarding the individual STEM discipline curriculums, highlight

the importance of STEM at present and give reason for much needed further research in the area. Furthermore, awareness and research regarding the need for early STEM exposure for children prevails. In reviewing this literature, a lack of research on STEAM education in ECE in Ireland comes to light.

Chapter 4: Methodology

4.1 Introduction

An overview and critical analysis of the literature on LS and STEAM were provided in the previous chapters. This chapter describes the research methodology that was used, the research question, embedded questions, and the justification for the study design. There will be an explanation of the paradigm, strategy, sampling strategies, data gathering tools, and ethical considerations. Following this an account of each of the research cycles is provided. Finally, the research choices taken in relation to data analysis, limitations, validity, reliability, and reflexivity will also be presented and supported.

4.2 Research Question and Embedded Questions

4.2.1 Research Question

Having reflected on their personal biography and social context, the researcher decided on the main research question:

What are the characteristics of an effective STEAM lesson in early years education?

4.2.2 Embedded Questions

- In what ways (if any) does teachers' STEAM education practice change due to engaging with LS?
- What are teachers' learning experiences of STEAM education?

- What are teachers' perspectives of LS as a form of CPD?

As STEAM education is at an exploratory and early phase (Leavy et al. 2022), this study aims to contribute to its development in early years (5-7) through engagement with six STEAM LS cycles in the early years. Whilst the researcher had some experience with LS, the participants did not. Therefore, this study offers rare insight into STEAM education in the early years and also Irish primary teachers' experience of LS.

4.3 Lesson Study

This research adopted a LS approach in determining effective characteristics of STEAM lessons in the early years. As discussed in previous chapters, LS, originating from Japan, is a collaborative professional development method centred on refining teaching practices through iterative cycles (Fernandez 2002). Educators work together in designing and teaching a lesson, observing its implementation, and making necessary changes. This approach promotes learning, the exchange of expertise, and the improvement of teaching methodologies, all aimed at enhancing student learning outcomes (Lewis 2002). Lewis (2002) states that through such collaborative and systematic exploration, LS enables the most effective elements of a lesson to be uncovered.

It is for such reasons that the researcher decided to use LS as part of this research. This study is an exploration of what a STEAM education lesson should look like in the early years.

While also acknowledging the teacher's experience with LS. Despite being regarded as a valuable professional development strategy and tool for improving education (Fernandez 2002; Lewis 2002), LS too has its implications and limitations. LS can be very time consuming and requires much coordination and collaboration from its participants (Lewis 2002). Furthermore, the success of a LS relies on the quality of collaboration and knowledge of the participants (Fernandez 2002). To prevent such issues in this LS, the researcher

selected participants who were eager to learn about STEAM education, who had the time it required, and the researcher helped reduce time demanded from the participants by collecting the resources needed and scheduling meetings at suitable times for all.

4.3.1 The Features of this Lesson Study

This LS involved the implementation of six LS cycles with 5–7-year-olds. The school wherein the research was conducted is located in Dublin in an urban area. It is a junior school with 500 pupils currently in attendance. At present, the school does not place an emphasis on STEAM or STEM education, therefore the two teachers participating in the study, one male and one female, did not have vast experience, if any, with STEAM education.

4.3.2 Aims of this Lesson Study

The research aimed to uncover the characteristics of a good STEAM lesson in early years education. LS was used as a vehicle to determine such knowledge. This lesson study is intended to serve as a guide for other teachers who wish to implement early years STEAM education lessons.

4.3.4 Role of the Researcher in this Lesson Study

In this LS, the researcher served as both the LS facilitator and knowledgeable other. In the role of facilitator, they guided the collaborative planning, observation and analysis of the lessons among the participants, ensuring the process remained focused and productive. As the knowledgeable other, the researcher provided insights and feedback, drawing on their experience and understanding of the subject matter. This dual role enabled the researcher to support the participants throughout the LS process. Taking on this dual role while arduous, it is not unique. There has been practice in this area where the researchers assumed both roles (Hourigan and Leavy 2023).

4.4 Paradigm and Approach

For the purpose of this research, a constructivist paradigm was chosen by the researcher to serve as a foundation for LS in the context of STEAM education. This paradigm is situated on the idea that learners actively generate their own knowledge through practical applications and engaging interactions with the learning environment (Piaget 1973). The constructivist paradigm encourages teachers to engage in discussion, offer scaffolding, and provide students with the opportunity to work together on challenges that integrate several STEAM disciplines. The LS intended to develop students' creativity, critical thinking, and capacity to link ideas across the STEAM spectrum by adopting a constructivist perspective.

The constructivist paradigm is a significant method for qualitative research that is based on the notion that people's experiences and interactions shape reality (Guba & Lincoln 1994). By examining participants' perspectives, narratives, and lived experiences, researchers conducting qualitative research using the constructivist paradigm aim to examine and comprehend the reality of the subject at hand (Guba & Lincoln 1994). This entailed accepting the notion that knowledge is jointly generated by the researcher and participants, as well as the researcher's responsibility in directing the research process.

4.5 Sampling

For this study, sampling strived to establish an accurate representation of the study's participants. A non-probability sampling strategy, purposive sampling, was chosen for this study which entailed selecting individuals who have particular traits or experiences that are pertinent to the research topic (Palinkas et al. 2015). The relevance and depth of the study were increased by allowing researchers to choose participants who can offer rich and in-depth insights into the research issue (Palinkas et al. 2015). In this case, as the study focused on early years education, the chosen participants were early childhood teachers. In qualitative research, deliberate sampling is frequently enacted to make sure that the chosen participants

can provide useful insights and data to answer the study's objectives (Patton 2002). As previously noted, the research was conducted in two senior infant classes in the school.

It is an urban, DEIS band 1, mixed, junior school. DEIS in Ireland stands for "Delivering Equality of Opportunity in Schools," representing a governmental effort to assist students originating from socio-economically disadvantaged environments. Schools under the DEIS program are sorted into various bands according to the extent of disadvantage in their respective catchment areas (DES 2017). A DEIS Band 1 school serves an area with the most pronounced levels of disadvantage. These schools commonly benefit from supplementary resources and assistance to tackle the obstacles confronted by students in these regions (DES 2017).

Class Total	Boys	Girls
Class 1 (Teacher 1): 25	11	14
Class 2 (Teacher 2): 25	10	15

Table 2: Size and Composition of Classes

4.6 Research Ethics

In educational research, specifically, ethical issues have the potential to be highly delicate and difficult. Every attempt was made to abide by the norms of research ethics as this study engaged teachers and involved the presence of children. In January 2023, ethical approval was received from Mary Immaculate Research Ethics Committee (MIREC). This required submitting a detailed document with a description of my research study, research methodology, sample interview questions, participant selection, ethical issues and implications for consent, anonymity and confidentiality, and the storage of the materials.

4.6.1 Participant Selection and Informed Consent

From the beginning, participants were fully informed of the study's objectives. The principal and board of management were made aware of the goals and methodological framework of the research process before it began. The principals and board of management received information letters detailing the goal of the study. With the help of these letters, participants' rights were guaranteed to be upheld both during and after data collection (Creswell 2009). The letters also included the essential data needed by participants to decide for themselves whether or not they wanted to participate (Bryman, 2012). Subsequently, the principal and board of management approved, and written consent was obtained (Appendix A + B).

Two teachers were initially approached and asked to take part in the study. They were chosen in accordance with the purposive sample technique based on who could best provide insight into this subject. They were two senior infant teachers who already had a strong collaborative professional relationship. After discussion and reading the information letter, the two teachers agreed, and consent was obtained (Appendix C).

Teacher	Class	Position	Teaching Experience	Gender
Teacher 1	Class Teacher	Permanent	≥ 10 years	Female
Teacher 2	Class Teacher	Fixed Term	1 year	Male

Table 3: Overview of Teachers

I placed significant significance on ensuring that my research was conducted within strict ethical guidelines as it involved school children. An information sheet and consent form was distributed to parents, to describe what I was doing and ask for their permission to allow their children to participate in the study. I explained how the focus of the researchers was not on

the children but on the teachers' and their own developing the practice. The form had an 'opt out' option also (Appendix E + F).

Although the children were not recorded, the children in the two senior infant classes became research participants. Therefore, I considered it important for the study that neither the kids' children's parents nor I made them feel pressured to participate. Following the suggestion that 'statements of purpose should be simple, straightforward and understandable' (Patton 2002, p. 407) for children, I articulated the objective of the research using appropriate language for children and asked if they would like to take part (Appendix F). I explained to them that much like themselves, I too attended school. and that I wanted to find out about the best ways of helping them learn and teachers teach, and asked would they help. Following this, I gave the children the form and instructed them to fill it out by choosing the relevant smiley face and signing their name if they wanted to participate (Appendix G). Before any respondent participated, I ensured that all consent forms were completed, returned, and signed.

4.6.2 Participant Withdrawal

All participants were reminded that their participation was fully optional and that they might withdraw at any time. Contact information (email address and telephone number) for the MIREC Administrator was provided to the participants (Appendix A, B, C, D, G, and H) to help with any questions. This was done to guarantee that participants did not feel compelled to join or that a power relationship existed.

4.6.3 Confidentiality and Anonymity

In order to preserve the confidentiality and identity of the participants, pseudonyms were also utilised throughout the study. The teachers were given the aliases Anna (Participant 1) and Jamie (Participant 2) to protect their anonymity. Even with the best of intentions, Manning (1997) warns that complete anonymity and confidentiality cannot be guaranteed because in

this case my friends, family, and coworkers knew where I taught. Anonymity cannot be ensured because it is likely that communities, families, and teachers could deduce participants' identities due to their familiarity.

To preserve anonymity, all gathered data, field notes, observations, and interview transcripts were kept on a password-protected computer.

4.6.4 Care and Protection of Participants

Participants, parents, the principal, or the larger school community were not intended to experience any worry or trouble as a result of this research. Throughout the study, I did not attempt to impose any kind of authority over the participants. This study made every attempt to ensure that individuals benefited from their involvement, as opposed to doing any harm.

Additionally, I made sure that Jamie and Anna were always involved and made choices regarding the research and its implementation. Both teachers have up to date Garda vetting. Garda vetting in Ireland involves examining the criminal records of individuals applying for jobs or volunteer positions, especially those that entail unsupervised interaction with children or vulnerable adults. The term "Garda" pertains to the Irish police force, known as An Garda Síochána.

4.7 Research Cycle

In the section that follows, the six LS cycles are described in detail. This comprises school meetings, interviews that were undertaken over each LS cycle, and a PD session.

Additionally, succinct elements of each STEAM lesson are provided. Chapter 5 will explore the lesson details, decision making and background in greater detail. The planning phase was undertaken from January to February 2023. This concerned explaining the research in a

meeting with the principal, meetings with the teacher participants and providing information sheets and consent forms.



Figure 10: Lesson Study Planning Phase January to February

The cycles of LS began in February 2023 and extended over a four-month period until May 2023. Altogether this research included a pilot study followed by five cycles of LS (Table 4).

LS Cycle	Lesson	Teacher	Topic	STEAM Disciplines
Pilot Cycle	Research Lesson 1	Jamie	Construction	Visual Arts, Science & Engineering
	Revised Research Lesson 1	Anna	Construction	
Cycle 2	Research Lesson 2	Jamie	Beebots	Science, Technology and Visual Arts.
	Revised Research Lesson 2	Anna	Beebots	
Cycle 3	Research Lesson 3	Anna	Sound	Music and Science
	Revised Research Lesson 3	Jamie	Sound	
Cycle 4	Research Lesson 4	Anna	Light & Shade	Science and Visual Arts
	Revised Research Lesson 4	Jamie	Light & Shade	
Cycle 5	Research Lesson 5	Jamie	Shape & Space	Maths, Visual Arts and Technology
	Revised Research Lesson 5	Anna	Shape & Space	
Cycle 6	Research Lesson 6	Anna	Drama	Drama and Science
	Revised Research Lesson 6	Jamie	Drama	

Table 4: LS Cycles

4.7.1 Pilot Cycle

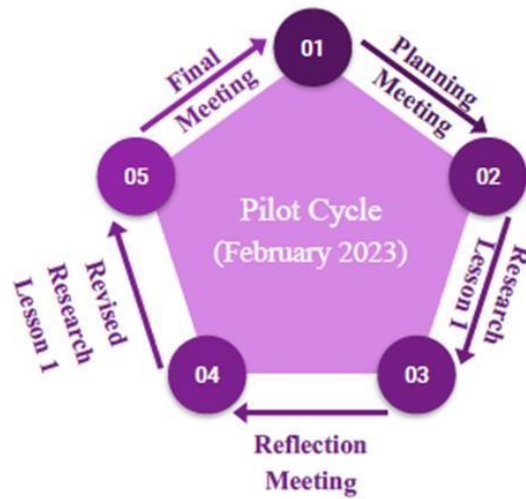


Figure 11: Pilot Cycle

The pilot LS cycle began in February 2023. Prior to this cycle beginning, the researcher and the participants engaged in informal conversations regarding the LS process and STEAM education. Additionally, prior to the LS process beginning, the first semi structured interviews were conducted. The participants were interviewed on their current perceptions and understanding of STEAM education and LS (see appendix J for interview protocol). During the first planning meeting, for guidance, the researcher discussed with the participants previous STEM lessons that the researcher had participated in creating while in college. Following this discussion, the team collaborated to create the first STEAM lesson with a focus on Visual Arts, Science and Engineering. The lesson challenged the children to build a Bee house that could withstand a storm. A bee puppet was introduced as a stimulus.

4.7.2 Cycle 2

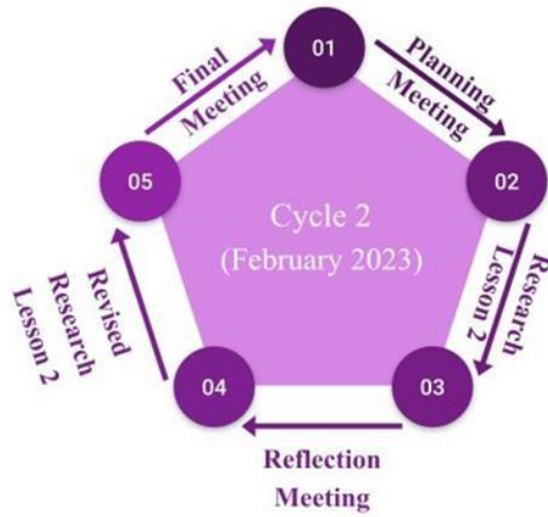


Figure 12: Cycle 2

Cycle 2 took place at the end of February 2023. There were no interviews during this cycle but during the collaborative meetings informal conversations regarding STEAM education took place. Observations were made by the research during such conversations. The second lesson was designed with a focus this time on Science, Technology and Visual Arts. The children were given the task to use the BeeBots to pollinate flowers which they had designed.

4.7.3 Cycle 3



Figure 13: Cycle 3

Cycle 3 began in March 2023. The participants and the researcher designed a STEAM lesson with a focus on Music and Science. The stimulus for this lesson was ‘The Flight of the Bumblebee’ composed by Nikolai Rimsky-Korsakov. The challenge for this lesson was for the children to create their own flight of the bumblebee using a variety of percussion instruments and body percussion. Semi-structured interviews (see table 7 below) took place following this LS cycle. The participants were interviewed on their experience of LS so far, any changes in their understanding of STEAM and on the STEAM lessons completed thus far (see appendix J for interview protocol).

4.7.4 Cycle 4



Figure 14: Cycle 4

In March 2023, the fourth LS cycle began. The focus of this lesson was on Science and Visual Arts. This challenge involved the children designing flowers using bun cases and deciding where would be best to plant them in a garden to grow. No interviews took place during this cycle.

4.7.5 Cycle 5



Figure 15: Cycle 5

Cycle 5 began in April 2023. Lesson 5 focused on Mathematics, Visual Arts and Technology. The children explored hexagons before creating a digital storybook of hexagons in the environment. No interviews took place in this cycle. During this cycle the researcher attended a PD course on bees and relayed information from the course back to the participants.

4.7.6 Cycle 6

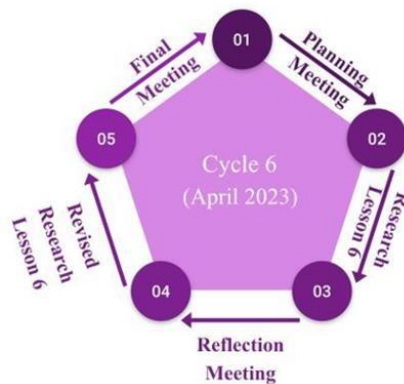


Figure 16: Cycle 6

The final cycle took place in April 2023. The participants used information gained from the

PD course on bees when planning the final lesson. The final lesson was focused on Drama and Science and the children enacted a role play of how they were going to help save the bees. Semi structured interviews (see table 7 below) took place subsequent to the final collaborative meeting. The participants were interviewed on their understanding of STEAM education, experience of LS and regarding the STEAM lessons (see appendix J for interview protocol).

4.8 Data Collection Instruments

Data Method	Activity	Participants	Pilot Cycle	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6
Interviews	Semi Structured Interviews	Anna	X		X			X
		Jamie Researcher	X		X			X
Document Reviews	Collaborative Lesson Plans	Anna	X	X	X	X	X	X
		Jamie	X	X	X	X	X	X
		Researcher	X	X	X	X	X	X
	Observations	Anna Jamie Researcher	X	X	X	X	X	X
Discussion Meetings	Collaborative Meetings	Anna	X	X	X	X	X	X
		Jamie	X	X	X	X	X	X
		Researcher	X	X	X	X	X	X

Table 5: Data Collection Methods

Table 5 outlines the various data collection methods engaged throughout the research project.

4.8.1 Semi Structured Interviews

For this study, the researcher employed semi-structured interviews as a methodological approach to demonstrate a strategic yet flexible approach to data collection (Robson 2002). By embracing the flexibility and adaptability inherent in this method, the researcher could

effectively delve into complex research topics (Bryman 2012; Robson 2002). By using openended questions within the semi-structured interviews, it enabled a comprehensive exploration of the participants' understanding of STEAM education. Furthermore, when participants deviated from the main topic, the researcher's use of probing techniques redirected the conversation, ensuring valuable insights are obtained (Mathers et al 1998). However, it is important to acknowledge that while semi-structured interviews obtain rich data, they can be time-intensive endeavours, for both the researcher and the participants (Newcomer et al. 2015).

Throughout this LS, the researcher conducted six separate semi-structured interviews, with the two senior infant teacher participants. The initial interview for both participants took place prior to the first LS cycle (January 2023). The second interview took place after the third LS cycle (March 2023), and the final interview took place following the completion of the six LS cycles (May 2023). The interviews varied from 20 to 40 minutes. The purpose of the interviews was to hear and learn about the teachers' understanding of STEAM education, their experience of LS, their opinions on the effectiveness, positives, and challenges of the STEAM lessons and to follow the teacher's development regarding STEAM.

4.8.2 Lesson Plans

The information obtained from the lesson plans during the LS process is a vital element in showcasing the improvements made. Lesson plans function as guides for teaching, outlining instructional goals, approaches, and assessments. When examined within the context of LS, these plans offer important insights into teachers' intentions and pedagogies (Lewis 2002). Analysing lesson plans enables educators to uncover the underlying reasons behind their decisions and align them with desired learning outcomes. Through the evaluation of how objectives, activities, and evaluations correlate, teachers are enabled to pinpoint potential

weaknesses and alter their lesson plans accordingly. Furthermore, lesson plans work as a reference for subsequent observations, facilitating focused data collection and enabling participants to assess whether the pedagogies coincide with the participants initial intentions (Fernandez 2002). This cyclic feedback mechanism ensures that lesson plans adapt based on observed results and challenges, fostering an environment of continual enhancement in teaching and learning. As such, lesson plans serve as a dynamic data source that guides the ongoing improvement of pedagogical strategies within the LS framework.

For this study, the lesson plans were stored on a shared drive between the researcher and the participants. The team made the lesson plan template used in the pilot cycle. During each cycle, a copy of the first lesson, lesson plan was made at the reflection meeting and any changes made to this copy prior to the reteaching of the lesson were highlighted in red (figures 11-16).

4.8.3 Observations

Lesson observation is of significant importance for LS, as it serves as a critical tool for refining teaching practices and fostering professional development (Lewis 2002). By observing lessons conducted by colleagues, it provides participants with invaluable opportunities for collaborative reflection of pedagogical effective or not effective strategies in the lessons (Fernandez 2002; Lewis 2002). Lesson observation allows the participants to gain insights into different instructional approaches, share best practices, and collectively work towards improving student learning outcomes (Lewis 2002). By observing and analysing lessons, the participants are able to identify the most effective pedagogies, address challenges, and alter their approaches. This practice aligns with the key aspects of lesson study, which emphasises continuous improvement through cycles of planning, observation, and reflection (Fernandez 2002). Additionally, lesson observation cultivates a culture of open

communication and shared expertise among teachers, which in turn creates a dynamic learning environment (Yoshida 1999). The improvement of suitable pedagogies and the standard of education relies on observation, hence determining it as a crucial component of the LS process.

Throughout this study the non-teaching participant and the researcher observed each lesson (figures 11-16). The participants and the researcher made notes throughout the lesson and shared their observations in the reflection and final meetings of each LS cycle. The researcher recorded their own observations during each lesson and recorded the participants' comments and further observations in the collaborative meetings.

4.8.4 Collaborative Meetings

Collaborative meetings maintained a crucial role within the LS process, serving as a platform for the participants to engage in reflective discussions and joint decision-making. Such meetings provide a structured environment for teachers to collectively plan, evaluate, and enhance instructional strategies based on their observations and insights (Fernandez 2002). Through open conversations, educators can exchange their different viewpoints, pinpoint strengths and weaknesses in the design of lessons, and collaboratively suggest modifications to improve the lessons (Lewis 2002). These meetings foster a culture of shared knowledge, enabling participants to view each other's perspectives and experiences and in turn to develop more effective teaching approaches (Yoshida 1999). By capturing the insights of each of the group members, collaborative meetings within the LS process contribute to the ongoing enhancement of teaching pedagogies and the overall quality of the lessons.

When using the term collaborative meeting in this study, it includes the planning, reflection and final meetings. The teachers met in the first week of each lesson study cycle to plan the lessons and resources needed, and to make any PowerPoints that were needed for the lesson.

The planning meetings took place for 1 hour from 1:30 - 2:30 when the children had gone home, in the researcher's classroom. The teachers worked together when planning the lessons, all sharing their ideas and having an input in the design of the lesson. The NCCA's Curriculum Planning Tool was used to include and choose which curriculum objectives were going to be included in each lesson. It is a subject specific curriculum planner that allocates individual strands, strand units and content objectives on a class-by-class basis across all subjects. The participants were introduced to the LS template in the pilot cycle and this same template was used throughout each LS cycle.

Reflection meetings took place the day the first lesson was taught, for 1 hour in the researcher's classroom from 1:30-2:30. These meetings began with the teacher who had taught giving their opinions on what elements of the lesson they felt worked well or didn't work well. The researcher and other participant then shared their observations from the lesson before the team began making the necessary changes to the lesson plan. Discussion when making changes focused on the children's engagement in the lesson, their ability to complete the tasks, time management, and the development of skills for the students.

Final meetings took place in the researcher's classroom for 30 minutes. The same process took place during these meetings as in the reflection meetings. Any final changes were made and highlighted in yellow on the revised lesson plan.

4.9 Data Analysis

For this study, an inductive thematic analysis approach was chosen by the researcher.

Inductive thematic analysis requires drawing themes directly from the data without using prior classifications or theories (Braun & Clarke 2006). The theory can arise from the data due to the inductive component of thematic analysis, and themes come to life through the researcher's interactions with the participants. The six-phase method of thematic analysis

developed by Braun and Clarke (2006) is a methodical procedure for examining qualitative data and locating important themes. Despite it being a structured approach, this procedure allows for flexibility as the researcher switches back and forth between the steps.

Phase	Description of the Process
1. Familiarisation with Data	I collected, transcribed and read the data.
2. Generating Initial Codes	I used NVIVO and Google Docs to identify codes and themes.
3. Searching for Themes	I organised the codes into potential themes.
4. Reviewing Themes	This involved two levels of reviewing and refining the themes. Level one involved reviewing at the level of the coded data extracts. Level two involved this, but in relation to the entire data set.
5. Defining and Naming Themes	I defined and further refined the themes and analysed the data within them.
6. Writing the Report	The aim of the thematic analysis report was to tell the story of the data in a way which convinced the reader of the merit and validity of the analysis.

Table 6: Thematic Analysis (Braun and Clarke 2006)

4.9.1 Data Analysis Process

In order to elucidate the process of analysing the data, this section makes reference to several appendices. Appendix R provides an excerpt from the researcher’s observations and appendix S provides an excerpt from a transcribed interview. Appendix T showcases a sample of the initial codes generated at the beginning of data analysis. Subsequently, Appendix U presents a demonstration of thematic analysis using an interview. Appendix V showcases a sample of the organisation of initial codes and into potential themes. Finally, Appendix W displays the progression of a selection of codes and subthemes for the four primary themes.

Stage 1: Familiarisation with the data

The data from the interviews was transcribed (see appendix S). Where necessary, observation notes were expanded. Changes made to lesson plans and reasons were recorded on a google document. All of the data was read through once to become familiar with it before a second reading took place wherein potential or striking codes were recorded which would be further analysed in stage 2.

Stage 2: Generating initial codes

To begin, I began recognising recurring themes or interesting aspects within the data, and then coded the data. I used open coding and completed it initially on NVivo, then followed by Google Docs (see appendix T).

Stage 3: Searching for themes

After completing the initial coding process, I began reflecting on the codes, revisiting the data where necessary, and bringing them together to form relevant themes (see appendix U). To do so, I used Google Docs. Colour coding allowed for systematic organisation and coding of the qualitative data, enabling the identification of recurring themes. During this process, particular attention was given to seeking both confirming and disconfirming evidence for these emergent themes. This comprehensive approach ensured a balanced and nuanced understanding of the data, contributing to the overall validity and reliability of the study's findings.

Stage 4: Reviewing themes

At this stage, I reread the data again whilst conjuring the potential themes I had gathered in stage 3 (see appendix V). I reflected on whether or not the themes were relevant to the research question. At this time, some themes were removed whilst others had to be separated into two themes. The four themes that emerged at this stage were:

- (1) Progression in Understanding, Teaching and Valuing ECE STEAM
- (2) Fostering Autonomy and Inquiry in Early Education STEAM
- (3) Effective ECE Pedagogies for STEAM Learning
- (4) Navigating LS: Benefits and Challenges for Educators

Stage 5: Defining and naming themes

At this stage, I needed to pinpoint the particulars of each of the four major themes, therefore requiring further analysis of each. Each topic showcased a narrative that had to fit into the larger narrative of analysis (see appendix W).

4.10 Potential Limitations of the Study

Various limitations of this study were identified in the design of this research including, children's voice, generalisation, and researcher bias.

4.10.1 Children's Voice

Excluding children's voices from this study is a limitation that can undermine the validity of the research findings. By excluding the perspectives, opinions, and experiences of the students directly involved in the subject being researched, researchers miss out on valuable insights that children can provide. Children maintain an understanding of their own lives and experiences, which are unlikely to be fully captured through the lens of adult interpretations

alone (Alderson 2004). The involvement of children's voices in the research project, could have provided a more accurate representation of the characteristics of a good STEAM lesson for infants.

4.10.2 Generalisation

The generalisation of findings from a small-scale study is an obvious limitation that compromises the broader applicability of the research findings. Small studies which involve limited sample sizes, make it challenging to ensure that the participants adequately represent the larger population (Creswell, 2014). This limitation can result in an unrepresentative sample that does not reflect the diversity and variability within the greater population. Consequently, generalisations from the study may be inaccurate. This study was carried out over 5 months in an urban, junior school in two senior infant classrooms with two senior infant teachers resulting in a small sample size and short time period. Therefore, this research may not represent the larger population of infant teachers teaching STEAM education.

4.10.3 Researcher Bias

The limitation of researcher bias regarding a LS study can undermine the objectivity and credibility of research outcomes. When researchers maintain preconceived notions or personal beliefs about the subject being studied, their perspectives can inadvertently influence the study design, data collection, analysis, and interpretation (Creswell & Creswell, 2018). This bias can lead to selective observation, interpretation, and reporting of data, potentially skewing the results in a particular direction.

Given my role as the researcher for this study, researcher bias can be identified as another limitation of the research. Despite having some experience with LS, the researcher did not maintain that they were an expert in the area and instead adopted an interactive role within the study. Notably, it was the role of the researcher to initiate meetings, pose questions and

gather the data. Through self-reflection and awareness, the researcher strived to remove researcher bias throughout the duration of the study. Throughout the data analysis process, it was crucial to actively seek disconfirming evidence for the identified themes. This approach helped ensure a comprehensive and balanced understanding of the data. Additionally, involving other participants through member checking served as a valuable strategy. Their perspectives and input could either confirm or disconfirm initial observations, providing an important layer of validation and aided in eliminating potential biases in the findings.

4.11 Validity

Validity in research pertains to the degree to which a study effectively measures its intended parameters and produces results that are trustworthy (Creswell 2009). For this research, the researcher adopted various strategies to ensure validity.

Triangulation was used for this study as the researcher obtained data from a variety of sources including two participants, lesson plans and observations. Creswell (2009) states that collecting data from a variety of sources maintains validity. As semi-structured interviews and observations were used, which is a form of methodological triangulation, this makes the research more valid. Additionally, member checking was used as a validity strategy also. This involved the researcher relaying the findings back to the participants to ensure their point was articulated correctly. For example, to ensure the theme of teachers' confidence in teaching STEAM was accurately depicted in the findings, I implemented a member checking process with the participants. This involved sharing the identified theme with them and soliciting their feedback and insights. Their input not only validated the accuracy of the theme but also provided nuanced perspectives that enriched the overall analysis, ensuring an accurate portrayal of their confidence levels in STEAM instruction. Finally, the provision of contrary information was used from the literature reviews and the findings chapter. Incorporating

conflicting information is a validity approach that involves intentionally searching for data that challenge the researcher's initial assumptions (Creswell & Creswell 2018). By incorporating diverse viewpoints and contradictory data, researchers enhance the credibility of their study (Creswell & Creswell 2018).

4.12 Reliability

Reliability within a study pertains to the stability and consistency of the data collection techniques, indicating the degree to which comparable outcomes would emerge if the study were replicated in identical circumstances (Trochim, 2006). Guaranteeing reliability is important for establishing the trustworthiness of the findings. For this study, the researcher carefully examined interview transcripts to make sure they did not contain any errors that would have hampered data processing in order to assure dependability throughout the study. Similarly, to enhance reliability, the codes were checked during the coding process to ensure there was no change in the definition of the codes.

4.13 Reflexivity

Reflexivity, which entails understanding and addressing the potential impact of the researcher's background, experiences, and prejudices on the study process and conclusions, is a crucial component of qualitative research (Finlay & Gough 2003). In recognising how the researcher's viewpoints may affect data collection, analysis, and interpretation, it emphasises self-awareness and transparency (Finlay & Gough 2003).

In relation to this study, the researcher has experience both with LS and STEAM education in ECE. The researcher is aware of the uncertainty and lack of STEAM education in relation to ECE and wished to explore and engage other infant teachers in STEAM education as a result. The researcher adopted a reflective approach to their research work and addressed their personal bias using different techniques.

The first technique was self-reflection. Prior to beginning the research, the researcher self-reflected on their own beliefs, thoughts, and feelings. Before and after interviews and observations and prior to data analysis, the researcher again self-reflected on such. This helped the researcher clarify and be aware of their beliefs and separate them from the research at hand. Secondly, as previously mentioned, the researcher included the participants in discussions relating to the findings to ensure the findings were accurately depicted.

4.14 Conclusion

To conclude, this chapter serves as the foundational structure upon which this research study was conducted. The deliberate selection of LS stems from its ability to uncover answers to the research question. By employing interviews, observations and lesson notes, this research strives to encompass a range of perspectives and data in relation to STEAM education in the early years. Additionally, the adoption of inductive thematic analysis is anticipated to uncover intricate themes within the gathered data. This carefully crafted methodology is envisaged to yield noteworthy findings that contribute significantly to determining the characteristics of effective early childhood STEAM lessons. In the subsequent chapters, the findings will be expounded upon, aiming to provide a deeper insight on early childhood STEAM education.

Chapter 5: Findings

5.1 Introduction

The central research question guiding this study is ‘What are the characteristics of an effective STEAM lesson in early years education?’. Additionally, several embedded questions were explored; In what ways (if any) does teachers’ STEAM education practice change due to engaging with LS?, what are teachers’ learning experiences of STEAM education? and what are teachers’ perspectives of LS as a form of CPD? Following analysis of the collected data using an inductive thematic approach, four dominant themes emerged: (1) Progression in Understanding, Teaching and Valuing ECE STEAM, (2) Fostering Autonomy and Inquiry in Early Education STEAM, (3) Effective ECE Pedagogies for STEAM Learning and (4) Navigating LS: Benefits and Challenges for Educators. This chapter showcases the teacher participants’ perspectives and experiences through their experience of engaging with six LS cycles and is organised in relation to the four themes.

5.2 Progression in Understanding, Teaching and Valuing ECE STEAM

5.2.1 Moving From Perceptions of STEAM as Fun to an Interdisciplinary Approach Addressing Real World Problems

Initially the participants maintained little knowledge on STEAM and its implementation. They viewed STEAM as a fun lesson but did not recognise its value in the classroom. However, by the final interviews a change was evident in their understanding, knowledge of how to teach STEAM and in their value of STEAM education in early years education.

In each interview the participants were asked what is STEAM education to you? The initial interviews showcased both participants could define the acronym but maintained little

knowledge on its implementation in the classroom. Links were made between STEAM and STEM. 'I know it's linked to STEM education...it consists of science, technology, engineering, arts and maths but yeah that's kind of it.' (Participant 1). 'STEAM is science, technology, engineering, arts and maths.. that's about as much as I know about it.' (Participant 2). Such findings link closely with literature stating that many teachers lack knowledge on STEM and its implementation, therefore presenting the need for PD in the area (Bell 2016, Brown and Bogiages 2019).

Regarding the need for STEAM education, prior to the LS process, the participants noted that they believed STEAM education was important for the future. Participant 1 maintained less knowledge regarding the importance of STEAM education and relied on prior informal conversations with the researcher. 'From the conversations we've had, I know it's important to get the kids ready for the future, and the future workforce that we will need.' (Participant 1). Participant 2 showcased greater knowledge and value in STEAM education. 'STEAM education is definitely important given the vast and varied positions nowadays in science, technology, engineering. We need to educate children to fill these positions and keep society moving forward.' (Participant 2).

The midway interviews, which took place after engaging in three LS cycles, revealed a significant change in both participants' knowledge of how to plan a STEAM lesson and also their value of STEAM education in the classroom. 'I have a much clearer understanding of what a STEAM lesson should look like... we focus on integrating two of the disciplines and if others integrate also that's a bonus.' (Participant 1). 'Before these last few weeks, I had no idea how to structure a STEAM lesson. I saw it as a huge lesson that needed to incorporate all the disciplines, whereas now I know to focus on two disciplines when planning a lesson.' (Participant 2). When creating the lessons, the researcher discussed adopting an

interdisciplinary or transdisciplinary approach with the participants. It is evident in both the midway and final interviews that the participants now maintain an understanding of STEAM education as using an interdisciplinary approach which is favoured by much relevant literature (English 2016, Gomez and Albrecht 2013, Sanders 2008).

In regard to the value of STEAM education, Participant 1 noted ‘I believed STEAM or STEM lessons were just fun lessons, not practical everyday lessons but seeing the benefits, the high level of learning and engagement from all I’m eager to learn more of how I could facilitate STEAM lessons more regularly.’. ‘I’m really after seeing the great potential of STEAM education already. The lessons have really grabbed the attention of the students and they are learning so much in a singular lesson.’ (Participant 2). However, despite such developments being stated at this stage by the participants, the researcher observed comments made by the participants in recent meetings which would suggest they still believe STEAM lessons were just ‘fun’ lessons.

‘In today’s meeting, [Anna (Participant 1)], made comments about having to go do her ‘actual’ maths lesson tomorrow despite saying in her last interview that she sees the STEAM lessons as practical lessons now and feels like a high level of genuine learning is achieved.’

(Researcher, Cycle 4, Observational Notes, March 2023)

Final interviews conducted after the six LS cycles had taken place revealed a continuing focus on two disciplines when planning STEAM lessons by both participants. Further development of their knowledge of STEAM education was revealed regarding solving real world problems, using a thematic approach and using a playful approach for 5-7 year olds. ‘STEAM education should facilitate children to solve semi-real world problems. Using a thematic approach was very effective in engaging the infants and in supporting continuous

learning.’ (Participant 1). ‘STEAM education is supporting the children in solving real world problems, while adopting a playful integrated thematic approach.’ (Participant 2). As the participants' knowledge and understanding of STEAM progressed over the project, their final definition of STEAM links with a transdisciplinary approach as they recognise the importance of giving the children the opportunity to solve real world problems in STEAM lessons. A transdisciplinary approach to STEAM is recognised by researchers (English 2016, Sanders 2008).

5.2.2 Teacher’s Confidence and Change in Practice as a Surmountable Barrier in ECE STEAM

Confidence and changing their practice, presented as initial barriers for the teachers in teaching ECE STEAM. However, they did overcome the barriers with LS acting as a vehicle for this change.

Initially both participants lacked confidence in teaching STEAM education. The interviews affirmed that it was not something they had much experience with. ‘I wouldn’t be confident in teaching a STEAM or STEM lesson. To be honest it's not something that I have any experience with really. I’m kind of embarrassed to say that.’ (Participant 1). ‘I wouldn’t be confident in teaching STEAM no. I’m grand with teaching the disciplines alone but integrating them is overwhelming.’ (Participant 2).

At the midway point an increase in their confidence was evident. The participants found the collaborative planning beneficial in knowing exactly what to expect in the lessons and it was stated that watching one another teach during the LS process while they were nervous at first, it was an opportunity for them to learn from one another and become more confident in teaching STEAM education. "Planning together, having the lesson fresh in my head and seeing others teach it has been great in helping my confidence.’ (Participant 1). ‘Obviously when you’re doing something new, you’re going to be nervous but honestly after the first

lesson I felt much less nervous. Watching another teacher teach has been a fantastic opportunity for me. It helped calm my nerves, knowing what to expect in the first lesson especially.’ (Participant 2).

STEMERG (2016) discusses the negative outlook passed on to students when their teacher lacks confidence or knowledge in certain disciplines. Interestingly, Participant 2 in the midway interview mentioned a lack of confidence in teaching or integrating the Arts element into the upcoming STEAM lesson. ‘I know our next lesson has a focus on drama which is something I probably don’t teach enough of due to my own lack of knowledge or confidence in teaching it so this is something I’m nervous about.’ The area of assessment also arose as a concern at this time. ‘I know we’ve incorporated a lot of whole class discussions and observations but are there any more formal assessments that could be used. I feel like I’ve no physical proof of their learning.’ (Participant 2).

In the final interviews, the participants gave their advice to other teachers in relation to teaching STEAM education. The advice given by the two participants affirmed the confidence and knowledge they had gained throughout the LS process. They spoke of focusing on two disciplines per lesson, child led instruction/ activities, allowing the children to fail, and time management. ‘Focus on two disciplines.. ensure there is a lot of child centred learning.. allow the children a chance to fail and try again..group work is essential..use a timer!’ (Participant 1).

‘Don’t be afraid of it! If you break it down and say pick a maths topic you need to teach, think what other discipline can I bring into it..once you have this the rest falls into place and kind of makes sense. As you make these connections your creative side kicks in and you actually become excited for the lesson!’

(Participant 2, Final Interview)

The teachers lack of confidence and initial struggle with changing their practice was reflected in their views and experiences with the first few lessons.

During the midway interviews when in discussion regarding the participants least favourite lessons, both participants chose different lessons but for similar reasons regarding their own confidence. Participant 1 chose the first lesson and participant 2 chose the third lesson (Table 9).

‘I was most nervous for this lesson and introducing the engineering aspect. Also having the materials everywhere and letting the children off..I felt like the room would be a mess.’

(Participant 1). ‘I chose this lesson probably because of personal reasons. My own confidence in teaching visual arts wouldn’t be as high as other subject areas.’ (Participant 2).

In the researcher’s observational notes, it is evident that the observer and the researcher of these lessons felt both of the lessons were successful for the children and that at this stage the teachers were still adapting to the inquiry based learning approach and building their own confidence. ‘The first lesson went well. The children were enjoying themselves and learning.’ (Researcher, Cycle 1, Observational Notes, February 2023).

On further reflection and development, when reasked the question in the final interview Participant 1 chose the first lesson again, but furthered on their initial reasoning regarding personal confidence in teaching STEAM education and the pressure of having people observe your teaching. ‘It was definitely due to my own confidence in teaching a STEAM lesson. I was nervous having people watch me. If I was to do it now again, I think it would be different.’ (Participant 1). Participant 2 this time chose lesson four (figure 18) and reasoned

that this lesson was not as exciting personally in comparison to the other lessons. ‘This lesson felt very different to the others. It was shorter and more concise which I liked too but I just preferred the other lessons. I found them more exciting personally.’ (Participant 2).

5.2.3 Growth in STEAM Competency Across the Lesson Study Cycles

Despite the teachers struggling initially with confidence and changing their practice, their growth and progression in STEAM developed quickly. From analysis of the lesson changes, the interviews and the researchers’ observations, the findings suggest the challenges weren’t disciplinary content related but were time and content management.

Lesson Alterations

Lesson	L1	L2	L3	L4	L5	L6
No. of Changes	5	6	4	3	3	1

Table 7: Lesson Alterations

As seen in table 7, is the number of changes made to the lesson in each LS cycle. It is evident that significantly more changes were made in the first three lessons in comparison to the last three lessons.



Figure 17: Changes to Lessons 1, 2 and 3

In the first half of the intervention each of the lessons required changes including the addition or removal of resources and alterations to the layout of the lessons. A visual timer was added after the first teaching of lesson 1 due to issues with time management, and this remained a feature of the following lessons. Initially group sizes for the first lesson were four, but this was reduced to three after observation to increase children's voice and participation in activities. In the second lesson a lesson objective was removed as the lesson had too much content in it and when removed the remaining content was better achieved. Lesson 3 saw the introduction of peer assessment wherein the children gave feedback to others on where they had chosen to plant their flowers.

04	Flight of the Bumblebee	<ul style="list-style-type: none"> • Smaller groups • Additional support added • Self assessment added
05	Honeycomb Hexagons	<ul style="list-style-type: none"> • Resources changes • Circle time added • Additional support added
06	To Bee or not to Bee	<ul style="list-style-type: none"> • Lesson layout changed

Figure 18: Changes to Lessons 4, 5 and 6

Similar but fewer changes were made to the final three lessons. Additional support added to these lessons included images on the whiteboard, children as demonstrators prior to activities, and planned mixed ability groupings. Lesson 5 also saw the addition of circle time to discuss the features of the Storybook Creator app.

In summary, various changes were made to lessons across the study including changes adjusting content and structure, clarifying instructions and expectations, addressing student engagement, scaffolding, assessment, modifying materials, and timing. The number of changes made to lessons began to decrease after Cycle 2, showcasing the efficient growth in understanding and competency by the participants. Furthermore, the changes that were actually made in the lessons suggest that the main challenges faced by the participants were related to time and content management.

5.2.4 Growing Appreciation of STEAM in Early Education

Teachers' initial lack of merit in ECE STEAM evolved quickly as they saw positive results and changes in the classroom and in the children. Initial beliefs of little genuine STEAM

learning for early learners progressed to a realisation of STEAM as valuable interdisciplinary approach addressing real world problems.

Findings from the initial interviews showcase doubt in the teacher's value of genuine STEAM education learning in early years education. 'There probably isn't as much learning as you would have with older classes, but I do think it should be introduced to infants even to form a base.' (Participant 1). 'It's no harm introducing it to infants so that when they reach the older classes it won't be a completely new concept for them.' (Participant 2). These findings concur with literature maintaining that 'real' STEM learning does not occur in ECE, but its implementation is a beneficial base for future learning (Clements and Sarama 2016, McClure 2017).

However, following the LS process, a change in the participants' attitudes is evident as they discuss the high levels of learning evident from the children. 'I didn't realise how much learning could really come from engaging the children in STEAM lessons, especially infants. You can cover multiple topics in one lesson and the children really enjoy the lessons,' (Participant 1). 'Initially I felt like the lessons were just going to be a bit of fun for the infants and I kinda felt I'd have to cover the topics again outside of the STEAM lessons, I really didn't believe there was potential for such a high-quality learning experience until now.' (Participant 2).

Furthermore, the participants became aware of and more comfortable with adopting a child centred learning approach.

'I've been teaching quite a while now and have undoubtedly been using a more teacher-led approach. The idea of using a child centred approach sometimes to me felt like they were just playing. However, since having a more child centred approach these last few months it's something I want to continue in my classroom. They are discovering for themselves and are loving doing it.'

(Participant 1, Final Interview)

'As an NQT using a child centred approach is primarily what I've learned about in college but after teaching these STEAM lessons, it made me question if I've actually been using it in the normal school day to day. During these lessons when I was observing the children solve these challenges together it made me realise their potential which I think I may underestimate at times.'

(Participant 2, Final Interview)

5.3 Fostering Autonomy and Inquiry in Early Education STEAM

The efficient growth in STEAM competency and value appeared to have been the motivator in developing teachers' practice. Teachers recognised the power of STEAM as they began to see evidence of and develop appreciation for student autonomy in learning. Furthermore, they found that the children began to develop confidence, that STEAM supported inclusive practices and that problem driven learning was evident.

5.3.1 Developing Appreciation of Student Autonomy in Learning

At the beginning of this study, inquiry-based learning was a term that Participant 1 was not familiar with and Participant 2 was familiar with the term but did not believe they included it

much in their practice. During the initial planning meeting in the pilot cycle this term was discussed, and the participants researched online about it using the SFI and INTO websites. Throughout the LS cycles the teachers adopted an inquiry-based learning approach in their teaching. As this led the teachers to the idea of them as a facilitator, following the first lesson challenges were evident as they attempted to change their practice.

'I was a bit nervous for this lesson and throughout this feeling lasted. I felt like the classroom was a mess with all of the materials and allowing them to just freely design the bee house as they wished. It stressed me out a bit.'

(Participant 1, Midway Interview)

From this it is evident that Participant 1 struggled with the active and hands-on nature of STEAM lessons. Participant 2 had a similar feeling in relation to feeling nervous and in the interview highlighted their struggle with adopting the teacher as facilitator role when they acknowledge that usually a more teacher led approach would be used.

'I enjoyed the lesson but at times felt a bit lost. I felt like I should be doing more. I'm not used to taking that much of a step back and letting the children work away on an activity like that.'

Usually when doing a big art activity we would do some parts step by step together.'

(Participant 2, Midway Interview)

Notably, their comments contrasted greatly to the researchers' observational notes from both the lesson itself and the reflective meeting in the pilot cycle.

'The children seemed to be really enjoying the lesson. They were working well together and communicating with one another to contribute to the design of the houses. [Participant 2] said it felt like there was a buzz in the classroom when observing [Participant 1] and was surprised at how well the children worked independently.'

(Researcher, Cycle 1, Observational Notes, February 2023)

Despite the teachers being aware of and understanding the idea of the teacher as a facilitator, it took a while for this to be something they were comfortable with. However, as the time progressed inquiry-based learning became something that both participants became much more comfortable with as they could see the benefits of it. In their final interviews both participants mentioned various benefits they could see from adopting this approach such as enhanced engagement, deeper understanding, the development of 21st century skills and responsibility for their own learning.

'The children are learning for themselves...they are not relying on me for answers and as a result I have more time to move around the classroom and engage with and observe the children. In this time I could see they were all engaged and had an understanding of the content.'

(Participant 1, Final Interview)

'All of the children were engaged.. It was amazing! [laughs] Seeing them communicate with one another and solve the tasks together..some of them would make great leaders. The level of creativity was unbelievable. It really allowed them the chance to show what they could do and they were so proud of it.'

(Participant 2, Final Interview)

5.3.2 Children's Developing Confidence

Linking to the inclusive nature of the STEAM lessons, the participants witnessed changes in their children's attitudes towards the STEAM disciplines. When discussing any changes observed by the teachers of the children during or after the LS process, a recurring theme was the participation and confidence of all children.

'Children, even infants, can sense when others are stronger than them or they are weak in a subject area and they develop a negative attitude towards particularly maths from an early age. However, since integrating maths in the STEAM lessons, I noticed that all the children are eager to participate and have a lot more confidence in themselves.'

(Participant 1, Midway Interview)

This confidence was further recognised as the participants note the development of children's ability to learn from failure. Group work was the key methodology noted in this study for supporting students in being comfortable to learn from failure.

'The children have learned it's okay to make mistakes. They realise that they can make a mistake and come at a problem again and hopefully come to a better solution the second time. Working together really helped them with this I think and saved those who may get embarrassed.'

(Participant 2, Final Interview)

'Allowing children the time and chance to fail was eye opening for me. As a teacher I think sometimes we get so caught up with trying to get everything covered that things can be rushed but taking this time...it gave them a voice and a chance to make a mistake and learn from their mistake.'

(Participant 1, Final Interview)

In the first lesson, this was not something the children were familiar with and showcased some uncertainty and confusion when told to go back and see how they could change their bee houses to make them stronger.

'After testing the beehouses with the hairdryer, the children were asked to go back and see what they could do to make their houses stronger. Some children seemed surprised or confused by this. When they got back down to their tables, some were unsure of what to do and thought it meant restarting completely. It was obvious this idea was new to them.'

(Researcher, Observational Notes, Pilot Cycle, Feb 2023)

However, during the fifth lesson wherein the children were exploring hexagons their ability and confidence to fail and try again had increased.

'When building the hexagons the children kept trying and trying. They loved the challenge of making the hexagon bigger and bigger. The support of a partner worked well for this activity. It was enough support whilst still ensuring that both children were involved.'

(Researcher, Observational Notes, Cycle 5, April 2023)

Learning from failure is a fundamental aspect of STEM Education. Encouraging students to embrace failure as a part of the learning process can promote critical thinking, problemsolving skills, resilience, and a growth mindset, all important 21st century skills (Thibaut et al. 2018).

There are several potential reasons for the positive changes witnessed by the participants and the researcher such as the hands-on learning approach, the relevance of the content to everyday life, the inquiry-based learning approach, the addition of the Arts or a combination of these reasons. However, such changes are welcomed as literature states that positive changes in attitudes can lead to increased engagement, better learning outcomes, and a greater willingness to pursue related fields in the future (Huling & Speake Dwyer 2018)

5.3.3 STEAM Supported Inclusive Practice

The potential of STEAM education to offer inclusive learning opportunities that cater for diverse student needs has attracted compelling attention. Creating a learning environment for students with a variety of backgrounds, skills, learning styles, and interests is referred to as inclusive learning in the context of STEAM (Leavy et al. 2023). This study concurs with such, as both participants note the increased engagement, participation and learning for all their students, particularly those who may have struggled with Maths. ‘In the STEAM lessons I felt the content was accessible to all as they were going in with confidence and the pressure was removed.’ (Participant 1).

‘Often in numeracy lessons, some children who would struggle would disengage from the lesson easily or would seek a lot of support before attempting an activity but in these lessons when the content was presented to them as a challenge or as a STEAM lesson this wasn’t the

case. They were all eager to complete the task...by presenting [the content] differently they were eager to try and it allowed them to show their learning in different ways.'

(Participant 1, Midway Interview)

'I feel like more kids are involved and taking part in the lessons that wouldn't always have engaged easily in lessons before...sometimes in maths lessons you could tell they feel selfconscious compared to their peers..I know they are only infants but at that age they do still have that self-awareness.'

(Participant 2, Midway Interview)

In their final interview the Participant 1 reiterated the inclusive nature of the STEAM lessons that they had witnessed, noting how seeing positive changes in their children inspired and motivated them in changing their practice.

'It's a way of including all learners in the classroom...and when you can see these changes in children it motivated me to make such changes even outside of the STEAM lessons we designed. The changes were often small but were effective...by simply introducing the lesson as a challenge or adding a theme they find interesting really increased the levels of engagement and participation.'

(Participant 1, Final Interview)

5.3.4 Problem Driven Learning

Interestingly when discussing their favourite lessons or which lessons they thought were the best, mentioned in each of the participants midway and final interviews was the idea of the children effortlessly learning throughout the lessons. ‘They were learning how to code without even realising they were doing it.’ (Participant 2). ‘They were subconsciously learning throughout the lesson.’ (Participant 1). Participant 2 stated ‘even certain children in the class who struggled with maths didn’t really realise they were doing it in these lessons and were doing well.’

Whilst literature notes some benefits of effortless learning such as efficiency, retention, positive habit formation and reduction of stress, there are also several negatives such as lack of awareness and limited or incorrect understanding (Dienes 2014). Evidently in this case from the teachers’ perspectives one benefit of effortless learning was the reduction of stress and in turn the confidence to engage and participate as a result. Furthermore, whilst assessment did take place during each lesson which showcased understanding and learning from the students, as this research did not study and record the students learning and development from the project, there is potential that such effortless learning may have resulted in a lack of awareness or limited understanding of concepts for some children. Despite the participants noting effortless learning as a key aspect of the lessons in aiding children’s learning, with the negatives in mind the question remains should early learners learn STEAM education effortlessly or be aware of the topics at hand. The content achieved in the lessons was discussed and reiterated at the end of each lesson.

5.4 Effective ECE Pedagogies for STEAM Learning

During the data analysis phase, a close review of the lesson plans, along with other pertinent data sources, was undertaken to pinpoint the STEAM pedagogies that exhibited effectiveness in the lessons. This involved examining how instructional methods and content were integrated, as well as assessing the overall structure of the lessons in relation to STEAM principles. This process led to the identification of several distinct approaches, each offering its own set of strengths and potential for enhancing STEAM learning in early childhood education.

5.4.1 ECE Pedagogies Common with Young Learners

The analysis of the lesson plans involved a detailed examination of the instructional approaches and pedagogies employed throughout the lessons. This process aimed to discern the specific strategies and methods utilised by educators to facilitate effective learning experiences in the context of the curriculum.

Group work, technology and the use of the puppet were noted by both participants as key aspects of the lessons. See table 8 for the pedagogies used in each lesson.

Lessons and Pedagogies

Pedagogies	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
Puppet				X	X	
Group Work						

Pairwork	X	X	X	X		X
WCD						
Redesign		X	X		X	X
Video & Focus Q	X		X			
Powerpoint & Images						X
Questioning						
Peer Review	X	X				
Child Centred Activity						
Think/ Pair/ Share	X	X	X	X		X
Story		X	X	X	X	

Show & Tell		X				
Child as Demonstrator	X		X			
Independent Activity	X	X		X	X	X
Circle Time	X	X	X			X
Warm Up Game	X	X	X	X	X	
Teacher in Role	X	X	X	X	X	

Table 8: Pedagogies and Methodologies Used

When asked which pedagogies worked best in the lessons both participants mentioned group work and referred to its ability to support children and also develop the skill of working collaboratively. ‘Group work ensured they all felt confident and weren't scared of failure and also they were working collaboratively which is a very important skill to develop in the infant years.’ (Participant 1).

‘Definitely groupwork or pairwork. The children were taking on challenges together and communicating with one another. They didn't always solve the challenges the first time round but I noticed children who would often give up kept trying with the support of their group.’

(Participant 2, Final Interview)

Another pedagogy repeatedly noted by the participants was the use of visual supports the lessons, particularly short video clips and pictures. 'Using a variety of sources in the lessons I believe really helped in maintaining the childrens' engagement and catered for everyone.' (Participant 1). 'The use of short video clips was brilliant to engage the children and an effective way of introducing new content.' (Participant 2).

The puppet used across the six LS cycles was mentioned by both participants also. The puppet served as a stimulus for many of the lessons, and the children were very excited and engaged when they saw the puppet appear. 'The excitement from the class each time the puppet appeared was brilliant. You could see the joy in their eyes. They were fully engaged and eager to see what the puppet had to say!' (Participant 1). 'The puppet brought a fun element to the lessons and really served its purpose as a stimulus. It was also great for me as the teacher, an easy but effective way to introduce a lesson or problem and it was a great classroom management tool.' (Participant 2)

Although not mentioned by the participants in interviews, whole class discussions, questioning, child centred activities, show and tell, peer review and child as demonstrator were used in several lessons. From the researcher's observations, show and tell and peer reviews were highly effective means of assessment.

'Show and tell was used again in lesson 5. The children got to show the other groups their digital story books which they were very proud of. The others were fascinated by designs that different groups had come up with. The peer review worked well with show and tell as the children shared what they liked about another groups work and what they would have changed if it was theirs. It was also a great opportunity for assessment.'

(Researcher, Cycle 5, Observational Notes, April 2023)

5.4.2 Technology as an Effective Resource in ECE STEAM

Throughout the LS cycles there were a variety of methodologies and pedagogies were used as evident in Table X. Certain methodologies were used across several lessons and were discussed in section 5.4.1 with group work, the puppet and visuals being identified as key aspects of the lessons. However, despite the participants initial lack of confidence yet efficient growth as discussed in section 5.2, this section illustrates further their efficient progression due to realisation of the impact of STEAM education in the early years.

The use of technologies such as BeeBots had a great influence on the teachers progression in STEAM value as they were a highly effective resource. When discussing which lessons the participants felt was the 'best' lesson during the midway interview, notably both participants said Lesson 2 (Table 9). The participants had no prior experience with using BeeBots and recognised the potential use of BeeBots across the curriculum. 'I've never used them before but I thought they were amazing..I think it was the most successful lesson so far and it made me realise I could use the BeeBots to teach other subjects also.' (Participant 1). 'I had no experience with BeeBots before but I loved them..this lesson opened my eyes to how they could be used in other lessons teaching literacy or anything really.' (Participant 2).

Interestingly, Participant 1 was surprised at the children's ability to use the BeeBots whereas Participant 2 linked the BeeBots with playful learning. 'I was sceptical before the lesson, I couldn't imagine the children being able to use them but again this links back to me and underestimating infants.' (Participant 1). 'It was definitely a very child centred lesson, very playful..the children felt like they were just playing but from their interactions you could hear the mathematical language and reasoning being used.' (Participant 2).Such findings link closely with that of previous studies which incorporate Bee-Bots that state incorporating BeeBots into early childhood education encourages young learners to embrace technology

and explore computational thinking in a playful and accessible manner (Bowen et al. 2023; Goodgame 2018).

'The BeeBots worked really well. The teachers were really impressed by them. We had to make a few changes when revising the lesson to make the instructions clearer for the children eg. press X to clear but in reteaching the lesson it worked really well. The children were playing, communicating, and discussing how they would get the BeeBots to pollinate the flowers.'

(Researcher, Cycle 2, Observational Notes, February 2023)

When re-asked the question in the final interviews, Lesson 2 was mentioned again in addition to Lesson 6 (Table 9). In early years STEAM education, maintaining the play aspect is of high importance. The final lesson was a role play wherein the children undertook roles of beekeepers, builders, and everyday people to act out scenarios and how they could help to save the bees. The teacher participants recognised this as a perfect ECE STEAM lesson which addressed a real-life problem in a playful manner.

'I felt the final lesson was a perfect depiction of what infant STEAM education should look like. They were learning science, addressing real world problems but in a playful manner. The drama and role play aspect of this lesson links with the principles of Aistear.'

(Participant 1, Final Interview)

5.4.3 Using an Integrated Thematic Approach in ECE STEAM

Participants in the study reported that utilising an integrated thematic approach in ECE STEAM greatly enhanced their teaching effectiveness. In terms of planning, they found that this approach helped in determining curriculum objectives. The thematic structure provided a clear framework, making it easier to align lessons across various STEAM disciplines. This

not only saved time but also ensured a more comprehensive and interconnected learning experience for students. Moreover, this approach boosted engagement levels among students. The use of the overarching theme of the bee sparked curiosity and enthusiasm, capturing the interest of young learners.

Lesson	STEAM Challenge
1	Construct a bee house using recycled materials
2	Use BeeBots to pollinate designed flowers
3	Design flowers and plant (place) them in a play garden where they will best grow
4	Compose your own 'Flight of the Bumblebee' using a variety of materials
5	Explore hexagons and create a digital story book
6	Think of solutions to help save the bees and illustrate through role play.

Table 9: The STEAM Challenges

For the purpose of this study, we adopted an interdisciplinary approach to teaching STEAM education. An interdisciplinary approach requires linking two or more disciplines to be taught together to deepen understanding (English 2016). From the interview data it became evident that the participants found this approach worked well and made planning the lessons manageable. 'When planning the lessons we always focused on integrating two of the disciplines. This made it very manageable to plan the lessons...so many areas of the different curriculums link together naturally.' (Participant 1). 'By focusing on integrating two of the disciplines it made planning easy to do...it didn't seem overwhelming or that the lesson was going to be too content heavy.' (Participant 2).

The findings from the final interviews in relation to the interdisciplinary integration approach used coincide with the data from the researcher's observational notes throughout the study.

'In the planning meeting today they seemed really confident in planning the lesson. They made comments about how focusing on two disciplines made the planning easier than you would expect for planning a STEAM lesson. The planning for [lesson 3] was much quicker and more seamless than before.'

(Researcher, Cycle 3, Observational Notes, March 2023)

Throughout each of the six LS cycles the same theme of the bee was used. The participants stated in interviews that they found using a thematic approach very useful to provide context and relevance to the content being taught. They also found that the theme of the bee helped in bringing together various STEAM disciplines under one overarching theme.

'Planning thematically and choosing the bee topic I think made it easier to integrate many different areas of the curriculum. We always had the idea of the bee in our heads and then looked at the curriculum planning tool to connect themes. Without this, I think the choice would have been overwhelming.'

(Participant 2, Final Interview)

'I felt that by using the bee and planning all over the lessons under this same theme, it gave both context and relevance to the lessons which for the infants is very important I think and for motivation also.'

(Participant 1, Final Interview)

Such findings coincide with related literature stating that using a thematic approach in STEM aids interdisciplinary connections, contextual learning, and engagement and motivation (Bybee 2002). Additionally noted in literature but not in the findings of this study, use of a thematic approach supports problem-based learning, collaboration, and creativity (Bybee 2002).

5.5 Navigating LS: Benefits and Challenges for Educators

Findings from the initial interviews showcase that neither participant had prior experience with LS but following the information letter and informal conversations before the project began they both maintained a basic understanding of the LS process. 'We're going to be designing a lesson together as a group then one person will teach the lesson then we'll look at what worked and what didn't before the lesson is retaught.' (Participant 1). 'I wouldn't have been familiar with it before but it's about planning together, teaching a lesson, reflecting on it, teaching it again and then doing a final evaluation I think.' (Participant 2). In both the midway and final interviews, the participants were asked about their experience of LS. Undoubtedly both benefits and challenges arose.

5.5.1 Benefits of Engaging in LS for Irish Primary Teachers

Several benefits coinciding with existing literature on LS arose from the study. The participants mentioned the collaboration aspect, improved teaching practice, reflection, enhanced student learning and long-term impact (Fernandez and Yoshida 2004; Lewis and Tsuchida 1998). Additionally, both participants mentioned they valued the support of their colleagues and noted the learning gained from one another (Quaresma et al 2018).

'I feel like we learned alot from one another even things not STEAM related and it was lovely to have the support when planning. Planning collaboratively, when you get into the routine of it makes it much easier and faster and ensures a high quality lesson.'

(Participant 1, Midway Interview)

'As an NQT, the support and planning together has been great. When you've done this extensive [laughs] planning together you know exactly what the lesson entails...also it's an opportunity to pick up methodologies or tricks from other teachers.'

(Participant 2, Midway Interview)

'The planning of this lesson was much quicker. We had a routine and I felt like everyone knew what they were doing. We had the curriculum planning tool up on the whiteboard, read through the objectives, discussed which we all thought would work well together and began filling in the lesson plan. I did the typing as we decided on the methodologies.'

(Researcher, Observational Notes, Cycle 3, March 2023)

In the final interviews, both participants restated the collaboration aspect. Additionally, the benefits of enhanced student learning, reflection and the long term impact were noted. This connects to literature by Fernandez and Yoshida (2004) who states that LS has the potential to enhance students' learning when teachers take the opportunity to study how students think and learn.

'LS not only benefited me professionally, but I feel the kids benefited also as they were receiving such high quality lessons which had been thoroughly planned and reviewed, and were accompanied with fabulous resources. They also experienced STEAM education for the first time as before this LS project it's not something I would have introduced in the classroom.'

(Participant 1, Final Interview)

In relation to STEAM in ECE, an evident benefit of this study was the ability of LS to act as a vehicle for change. The collaborative nature of LS not only honed pedagogical skills but also encouraged and supported the exploration of new and effective teaching methods in ECE STEAM.

'Taking part in the LS was a chance for me to reflect and think about my teaching. Being honest reflecting on my teaching is not something I do regularly but as I wish to keep up to date with these new concepts in my classroom like inquiry-based learning, I found reflecting helpful and enlightening!'

(Participant 1, Final Interview)

'This LS made me realise that STEAM education is something I want to continue in my classroom. I feel like I have a good idea what STEAM education in infants should look like now and I've seen the benefits...I feel like I could plan lessons by myself now.'

(Participant 2, Final Interview)

5.5.2 Challenges of Engaging in LS for Irish Primary Teachers

Similarly, to the benefits, the challenges noted in this study link closely to existing literature on LS. Challenges of LS that the teachers noted were that it's a time-intensive process, resource demands, and teachers are resistant to change (Chassels and Melville 2009; Flanagan 2021).

'It is time consuming, there's no doubt about that. It would take a full hour to plan a lesson. Then the resources need to be either created or sourced. Teach the lesson or get the time to observe the lesson. Reflect then go again before the final meeting. It is a lot.'

(Participant 2, Midway Interview)

'LS takes a lot of time from planning the lesson to the final meeting. A lot has to happen, and it doesn't and can't happen quickly with everything else going on in school. Another challenge I felt was changing my thinking and teaching. This was all new to me and at the start I struggled to embrace the more child centred approach and to take a step back.'

(Participant 1, Final Interview)

'There's a lot of work in facilitating LS. I don't want to put pressure on the participants but struggling to get meeting days that suit everybody...gathering all of the resources for each

lesson is also stressful and trying to store them in the classroom.'

(Researcher, Observational Notes, Cycle 3, March 2023)

Chassels and Melville (2009) investigated the benefits and challenges of LS in an elementary school setting and had similar findings with the addition of lack of expertise and measurement of impact.

5.5.3 LS as an Effective form of CPD for Irish Primary Teachers

CPD includes activities and experiences that support teachers' continual learning, development, and improvement of their skills, practice, and knowledge. This goal aligns with LS, which provides a collaborative and structured method of professional development (Flanagan 2021).

In their initial interviews, the participants stated that current CPD methods in schools lack engagement and while at times may be interesting, they do not follow up with the gained ideas, in their classrooms.

'We are all very used to listening to an in person speaker or a webinar online... and you might be inspired at the time but more often than not you forget about it and don't end up implementing it in your classroom.'

(Participant 1, Initial Interview)

'Any PD I've partaken in involves staying in school for an hour after a day's work, attempting to listen to someone speak while really I'm counting down the time... it lacks interaction and engagement.. goes against how we are meant to engage the children with hands-on activities and less teacher led instruction.'

(Participant 2, Initial Interview)

This coincides with current literature on PD stating that it should be active, content focused and ensure collective participation (Borko et al. 2010; Desimone 2009; Flanagan 2021).

In the final interview when asked about their experience of LS, both participants noted that LS would be a beneficial form of CPD with high levels of engagement and long-lasting results in the classroom.

'If LS was an option for PD in Irish primary schools that would be great.. I found it much more beneficial than having a speaker come in or watching something online... I had a voice.'

(Participant 1, Final Interview)

'I think it would make a great form of PD.. I'm learning on the job in a practical way.. And as I'm learning through experience the learning stays with you and you continue it in your classroom after.'

(Participant 2, Final Interview)

The participants' feelings on current PD in schools and their view on LS as a form of CPD concurs with literature that claims LS merges many of the recognised features of effective PD (Dudley 2013; Flanagan 2021; Lewis and Perry 2014).

5.6 Conclusion

In light of the literature, this chapter discussed the findings and conclusions reached after data analysis. Four themes were provided with several subthemes to give structure and provide insight into STEAM education in early years education through use of LS. The participants engaged in the LS process over six cycles to explore and examine STEAM education and STEAM lessons suitable for the early years classroom. Findings from the semi-structured interviews, observations and lesson notes suggest an understanding of ECE STEAM education as education that adopts a playful approach wherein children are required to solve challenges. Several methodologies and pedagogies were recognised as key aspects of these lessons such as group work, the use of a puppet and short video clips or photos. Adopting a thematic and interdisciplinary approach was highly acknowledged by the participants. Changes were made to the lessons including the addition of resources, support, visual timer and small group sizes. The participants and researcher noticed positive developments in the children's learning and engagement over the six cycles. Participants noted the inclusive nature of the STEAM lessons and effortless learning was found to have removed pressure and increased confidence in the children. Finally, the teachers' experiences of LS found it a time consuming task but valued the collaborative element, enhanced student learning and improved practice.

Chapter 6: Conclusions and Recommendations

6.1 Introduction

The final chapter begins by looking back at the research question and embedded questions that guided this study and provides conclusions to answer these questions. Following this, recommendations are provided for educators, policy makers, principals and future research. The limitations of this study are recognised before outlining the original contribution of this research. Finally, the chapter ends with a concluding reflection.

6.2 Research Question and Embedded Questions Conclusions

6.2.1 Research Question

What are the characteristics of an effective STEAM lesson in early years education?

This study uncovered several insights into the design and characteristics of an effective STEAM lesson for early years education. The teachers perceive STEAM as highly suitable and beneficial for 5–7-year-olds. The findings from this study, revealed several design aspects that made the STEAM lessons engaging, appropriate and of high learning for the children. The teachers maintain that adopting an interdisciplinary approach to teaching early years STEAM education was highly effective. They stated across interviews that such an approach is beneficial for both the students and the teachers. For the students, using this approach allowed the teachers to design lessons which integrate two or more disciplines in each lesson. This resulted in the students partaking in learning which provided a holistic and active experience wherein they were developing 21st century skills. For the teachers, using an

interdisciplinary approach helped them with planning as it provided a structure to integrate two disciplines at least and prevented them from feeling overwhelmed in doing so.

Furthermore, thematic planning for STEAM lessons was highly regarded by the teachers in this study. Planning thematically again aided the teacher's planning but more importantly served as a vital tool in engaging the pupils and provided a continuous stimulus across the six lessons. In this case, the theme of the bee and the bee puppet excited the children across the lessons and learning based around this theme continued and developed from lesson to lesson.

In relation to the design of the lessons, various pedagogies and methodologies were tried throughout the study. This study found the use of group work was a key feature of the lessons, however smaller group sizes ensured that all children were taking part. Group tasks gave the children confidence whilst also developing their communication, collaboration and leadership skills. With consideration of the limited attention spans characteristic of children aged 5 to 7, employing concise video clips and visual imagery has proven effective in sustaining their focus and providing an additional avenue for engagement. This aligns with the Universal Design for Learning (UDL) approach, which emphasises the incorporation of diverse modes of representation. Literature supports the notion that offering various media and alternative means of representation accommodates the diverse learning needs and preferences of young learners (Hall et al. 2012; Rose 2000). Whole class discussions were used in each of the lessons as a recap and form of informal assessment. Powerpoints with images served as an effective form of support. Each lesson encompassed an inquiry-based learning approach which ensured the children were active, learning through discovery and developing their critical thinking skills. Created stories or challenges regarding the bee

puppet were used in many of the lessons and the children loved to hear this and were always eager to help him. The lesson layout ensured the children had two activities to complete with little teacher time integrated throughout.

Regarding assessment, informal assessment took place at the end of each lesson with a whole class discussion. Additionally, peer and self-assessment were introduced in the lessons. As noted in the Primary Curriculum Framework (2023), ‘Assessment is a collaborative process’ (NCCA 2023, p.20). Peer reviews were very popular amongst the children and teachers. In this time the children commented on other groups' work, things they liked or things they would have done differently if they had done it. Self-assessment was introduced as ‘show and tell’ wherein the children discussed their own work, what they liked about it, didn’t like about it and anything they would do differently next time. Whilst initially the student’s struggled to criticise their own work, after practise and demonstration they began to do it. The teachers found both of these assessment techniques very useful and child friendly! The Primary Curriculum Framework outlines the desire to promote learner autonomy, encourage child voice, and develop life skills (NCCA 2023), hence self-assessment and peer assessment play a vital role. By incorporating these practices, educators support students in ‘being an active learner’ (NCCA 2023, p.8), ultimately preparing them for a lifelong journey of learning and growth.

6.2.2 Embedded Questions

In what ways (if any) does teachers' STEAM education practice change due to engaging with LS?

The findings from this research suggests that LS was beneficial in bringing positive changes to teachers practice (Dudley 2013; Flanagan 2021). Prior to this LS, both teachers had little or no experience with STEAM education or inquiry-based learning. LS helped the teachers in developing theory regarding early years STEAM education but also in turning this theory into practice. It provided a context for teachers to introduce STEAM education to senior infants in a supported environment which was focused on the children's learning. Inquiry-based learning was a new concept for the participants, and it took some time for them to adjust in terms of understanding and implementing this whilst adopting the role of teacher as facilitator. LS provided collaborative, observational and experiential support in adjusting their teaching to incorporate the inquiry-based learning approach.

What are teachers' learning experiences of STEAM education?

Prior to the LS the teachers were familiar with the term STEAM but were unsure of how to implement it in the early year's classroom. Additionally, they maintained the belief that early year's STEAM education was just a preparation for 'real' future STEAM learning however their opinions changed. The teachers learned how to plan and design early years STEAM lessons and witnessed great learning and engagement from the children which led them to seeing true value in STEAM in early childhood education. Adopting an interdisciplinary approach in designing STEAM education lessons was new to the teachers and something they found useful and effective. They looked closely at ensuring that the lessons entailed a playful aspect linking in with the principles of Aistear. Teachers found that it was possible to integrate the Arts into the lessons so that the Arts were being taught but they also found that integrating the Arts provided a gateway for those who may struggle with the Science or

Mathematics disciplines alone. This is an ongoing debate in literature (Leavy et al. 2023^[AL2]). The teachers felt positively that some children were engaged in effortless learning.

What are teachers' perspectives of LS as a form of CPD?

The teachers in this study perceived LS to be a beneficial form of CPD (Flanagan 2021). In their initial interviews, the participants spoke about current CPD in Irish primary schools and noted the lack of engagement, and long-term impact. When discussing their experience of LS in their final interviews, both participants maintained that LS would be a beneficial form of CPD. They stated the level of engagement and participation were high which resulted in a meaningful learning experience. As a result, the learning would have a long-lasting impact and would be something they continue in their classroom in the future. Whilst acknowledging the time-consuming nature, resources demands and initial resistance to change, the teachers praised the collaborative, improved teaching practice, reflective and enhanced student learning aspects of LS.

6.3 Recommendations for Teachers

Incorporating STEAM education into the classroom requires teachers to embrace an interdisciplinary approach that intertwines Science, Technology, Engineering, Arts, and Mathematics. To succeed in this endeavour, teachers should understand the interconnected nature of these disciplines and cultivate an environment of creativity and inclusivity. By engaging with aspects of the new Primary School Curriculum (2023) and providing hands-on experiences, promoting critical thinking, and fostering inquiry-based learning, teachers can guide students in applying knowledge to real-world contexts or problems. Collaboration, flexibility, and the integration of technology are essential components that mirror the dynamic nature of the STEAM disciplines. The STE draft specification (2024) illustrates a five step

approach to integrated STEM learning; Identify, Refine, Plan, Implement and Evaluate. Teachers should embrace this approach to aid the development of a STEM mindset and STEM Literacy in their students. This approach reinforces the notion that ‘ How children learn is as important as what children learn’ (NCCA 2024, p.21). This idea should be recognised by teachers with the new curricula being introduced.

When focusing on implementing STEAM education in the early year’s classroom, it is important that teachers utilise a thematic approach that will engage their students and provide potential for linking the principles of Aistear. Using easily accessible tools such as the curriculum planning tool and the new STE Online Toolkit, can aid teachers greatly in their planning of STEAM lessons as links can be easily made between disciplines. With the evolving nature of STEM and STEAM in the Irish primary context, teachers are responsible for their own learning and to meet the needs of the students. Through CPD, teachers can improve their knowledge, understanding and practice to facilitate students in developing 21st century skills.

6.4 Recommendations for Principals

This study showcased effective design of ECE STEAM lessons and the development of teacher’s understanding, knowledge, and practise of such through LS. As a result, it is advised that principals engage in effective school leadership, which can improve both student results and teacher instruction (DES 2018). Instructional leadership, which focuses on teaching and learning, states that it is the responsibility of the principal to give priority to the subjects that will benefit students the most (DES 2018).

Creating a thriving STEAM education environment for 5–7-year-olds requires principals to establish a safe and stimulating school environment that prioritises inquiry based and playbased learning. By offering comprehensive PD, promoting collaboration among teachers,

and maintaining open communication with parents and guardians, principals can ensure that teachers are well-equipped to implement the STEAM concepts into early years education. Through purposeful design of STEAM-rich activities, encouragement of observation and reflection, and support for innovative teaching approaches, principals can foster a strong foundation for 5–7-year-olds to develop essential 21st century skills.

In light of the new STE education specification, the need for PD and PD promotion is reinforced as teachers will require upskilling in their STEM content knowledge, pedagogies to address the new key competencies, and for some to develop their own ‘STEM eyes’. Additionally, investing in necessary resources and infrastructure to support would be of benefit in supporting teachers and students. For instance, the STE specification (2024) notes the importance of the development of computational thinking skills using digital technologies through the use of programming and coding. Schools should be equipped with such, and teachers may also require PD prior to use,

6.5 Recommendations for Policy Makers

In shaping policies for early years STEAM education, policy makers should prioritise the integration of the STEAM disciplines into early childhood curricula. By offering comprehensive teacher training, equitable access, and engaging family involvement, policies can ensure that 5–7-year-olds receive age-appropriate, STEAM experiences that stimulate the development of 21st century skills. These policies should be informed by research, collaboration with experts, and the establishment of clear standards that respect 5–7-year-olds’ unique developmental needs and link in with Aistear. Furthermore, in support of the new STE curriculum, the provision of funding or PD programmes to equip teachers with the necessary skills and resources is imperative. Adequate funding, assessment methods aligned with developmental stages, and flexibility with curriculum implementation are essential

components to consider. Ultimately, well-informed policies will foster a foundation for lifelong learning, equipping future generations with the creativity and problem-solving skills essential for success in an evolving world.

Additionally in relation to LS, at present LS is not a commonly known form of PD in the Irish primary context. Whilst there have been recent studies in Irish primary schools using LS (Flanagan 2021; Leavy and Hourigan 2016, 2018), further studies and developments are needed to recognise the potential of LS as a form of CPD for Irish primary school teachers.

Incorporating LS into education policies necessitates policy makers' commitment to promoting CPD. By allocating resources, advocating for professional learning communities, and collaborating with educational institutes, policy makers have the opportunity to create an environment conducive to LS implementation. Integrating Lesson Study into PD plans, recognising its impact, and emphasising teacher leadership will underscore its value as a school improvement strategy.

6.6 Recommendations for Researchers

This study revealed key characteristics of effective early years STEAM education lessons. However, a limitation of this study is its scale. The study involved two teacher participants and two senior infant classes in an urban junior DEIS school. Therefore, it is recommended that researchers conduct a longitudinal study on early years STEAM education that would investigate early years STEAM education in a greater cohort of schools of various socioeconomic demographics. STEAM education is a new concept to many in the Irish educational context, therefore research regarding its design, implementation, assessment, and learning are all welcomed.

Despite the fact that the new STE curriculum does not explicitly include STEAM, researchers may take the opportunity to evaluate explore opportunities to extend STEM into STEAM. Researchers could also examine the effectiveness of the new STE curriculum by tracking student outcomes, engagement and interest. There are also opportunities for researchers to examine equity and access issues of the STE education curriculum AND identify pathways to ensure that all students engage with STEM and STEAM.

6.7 Limitations of the Study

The study's potential limitations were noted by the researcher. Firstly, the researcher gathered data from two participants which makes the sample size of this study small. Whilst there were a variety of data collection methods used which add to the reliability of this study, maintaining a small sample size impacts the generalisation of the findings from the study. Finally, it is important to note, that this study was conducted in school with a specific sociodemographic (urban), and as a result, the study's findings reflect these research choices.

6.8 Original Contribution of this Study

This research adds to little research available on STEAM education in Ireland. Whilst some Irish studies have focused on STEM in early years education (Flanagan 2021), the researcher could not find any studies on STEAM education in early years education. As there is little research on STEAM in the Irish educational context, and little research on STEM in early childhood education, the findings of this study provide valuable insights into STEAM education for 5–7-year-olds. This study demonstrates how LS assisted educators in implementing new strategies for STEAM instruction with senior infants. As effective

STEAM practices research is still in its infancy, evidence-based professional learning is necessary to support instructors and comprehend good PD.

Furthermore, this research contributes to the evolving literature on LS in the Irish educational context. The study revealed insights into the benefits and challenges of LS for Irish primary teachers. Despite the short time span of this study, it showcased that LS had the ability to increase teacher's confidence, knowledge, understanding and implementation of STEAM education, a new concept to them, in this time period. At a time in Ireland, where curricular reform is evolving which will require intensive PD for teachers and principals, this is of considerable value.

With the recent introduction of a new primary curriculum in Ireland, and particularly a new draft specification for STE education, change in education is at its peak. Sustainability and integration are key features of the new curricula, both of which are addressed in this study. The STEAM lessons within in this study are examples of how STEAM education for 5–7-year-olds could be implemented, whilst addressing several features of the new and draft curricula. For example, pedagogical principles used in this study such as group work, redesign, questioning, child centred activities and show and tell coincide with the development of the new key competencies noted in the STE specification (2024).

6.9 Concluding Reflection

To conclude, this study explored the design characteristics of early years STEAM lessons to reveal effective practices through use of LS. Chapter 1 outlined the research question and embedded questions and examined the significance and applicability of infant STEAM education to current policy and practice. Chapter 2 critically examined the literature available

on STEAM education in ECE, before chapter 3 examining literature available on LS both nationally and internationally. Chapter 4 briefed the research methodology utilised and ethical considerations for this study. Chapter 5 showcased and discussed the findings that arose. Finally, chapter 6 illustrated the conclusions of this research before making recommendations for teachers, principals, policy makers and researchers.

Embarking on this research journey has been a deeply enriching and fulfilling experience for me. The opportunity to delve into the realm of early years STEAM education has not only expanded my own knowledge but has also provided a platform for collaboration and improvement in early childhood learning practices. The dedication and enthusiasm displayed by the teachers, the principal, and the children in participating in this study has been inspiring and motivating. Through this research, I have gained insights into the intricacies of early years development, learning and engagement within the STEAM framework. This study has not only illustrated effective STEAM methodologies on early years learning but has also reinforced the pivotal role of PD in fostering STEAM experiences. As I reflect on this journey, I am hopeful that the outcomes of this research will contribute to further developments on early years STEAM education. Just as this research has shaped my own practice, I aspire for it to inspire teachers to enhance their own practice, ultimately leading to an enriched foundation for lifelong learning in our youngest minds.

Bibliography

- Aguilera, D. & Ortiz-Revilla, J. (2021) "STEM vs. STEAM Education and Student Creativity: A Systematic Literature Review", *Education sciences*, vol. 11, no. 7, pp. 331.
- Bell, S. (2010) Project-based learning for the 21st century: Skills for the future. *The clearing house*, 83(2), pp.39-43.
- Alderson, P. (2004) *Ethics, social research and consulting with children and young people*. Barnardo's.
- Alghamdi, A.A. (2023) "Exploring Early Childhood Teachers' Beliefs About STEAM Education in Saudi Arabia", *Early childhood education journal*, vol. 51, no. 2, pp. 247-256.
- Bell, D. (2016) 'The reality of STEM education, design and technology teachers' perceptions: A phenomenographic study', *International Journal of Technology and Design Education*, 26(1), 61–79.
- Bergsten, C. & Frejd, P. (2019), "Preparing pre-service mathematics teachers for STEM education: an analysis of lesson proposals", *ZDM*, vol. 51, no. 6, pp. 941-953.

- Bevan, B. (2017) 'STEAM as a Social Practice: Cultivating Creativity in Transdisciplinary Spaces', *In Perspectives on STEAM Education*.
- Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of twenty-first century skills* (pp. 17–66). Dordrecht: Springer.
- Bowen, G.M., Knoll, E. and Willison, A.M., (2023) Using Bee-Bots® in Early Learning STEM: An Analysis of Resources. In *Exploring Elementary Science Teaching and Learning in Canada* (pp. 147-165). Cham: Springer International Publishing.
- Braun, V., & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics*, 112(1), 3–11.
- Brown, R. and Bogiages, C.A. (2019) 'Professional development through STEM integration: How early career math and science teachers respond to experiencing integrated STEM tasks', *International Journal of Science & Mathematics Education*, 17(1), 111–128.
- Bybee, R. W. (2002) Learning science and the science of learning. *Science Education*, 87(3), 402-416.
- Bybee, R.W., (2010) What is STEM education? *Science*, 329(5995), pp.996-996.
- Bybee, R.W. (2013) *The Case for STEM Education: Challenges and Opportunities*. USA: NSTA Press.
- Callahan, I. S. (2019). *Project luminous: An e-textiles workshop study to increase science technology engineering mathematics/science technology engineering art mathematics interest in middle school girls*. Master Thesis. University of Arkansas
- Champion, D. N. (2018). *The STEAM dance makerspace: A context for integration an investigation of learning at the intersections of STEM, art, making and embodiment*. Doctoral Dissertation. Northwestern University. ProQuest Dissertations Publishing
- Chassels, C. and Melville, W., (2009.) Collaborative, reflective and iterative Japanese lesson study in an initial teacher education program: Benefits and challenges. *Canadian Journal of Education/Revue canadienne de l'éducation*, 32(4), pp.734-763.

- Choi, G.Y. and Behm-Morawitz, E., (2017) Giving a new makeover to STEAM: Establishing YouTube beauty gurus as digital literacy educators through messages and effects on viewers. *Computers in Human Behavior*, 73, pp.80-91.
- Claymier, B. (2014) 'Teaching 21st century skills through an integrated STEM approach', *Children's Technology & Engineering*, 18(4), 5.
- Clements, D.H. and Sarama, J. (2016) 'Math, science, and technology in the early grades', *Future of Children*, 26(2), 75–94.
- Colucci-Gray, L., Trowsdale, J., Cooke, C.F., Davies, R., Burnard, P. and Gray, D.S., (2017) Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st learning: how can school curricula be broadened towards a more responsive, dynamic, and inclusive form of education?.
- Corcoran, D. (2007) Put out into deep water and pay out your nets for a catch: Lessons learned from a pilot study in mathematics lesson study. In S. Close, D. Corcoran, & T. Dooley (Eds.), *Proceedings of Second Annual Conference on Research in Mathematics Education* (pp. 275 – 289). MEI 2. Dublin: St. Patrick 's College..
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- Cunningham, C.M. (2018) *Engineering in Elementary STEM Education: Curriculum Design, Instruction, Learning, and Assessment*. New York: Teachers College Press
- Daugherty, M. K. (2013). The prospect of an “A” in STEM education. *Journal of STEM Education*, 14(2), 10-14.
- Department of Education and Skills (2017) *DEIS Plan, 2017: Delivering Equality of Opportunity in Schools*. Dublin: DES.
- Department of Education and Skills (2015a) *Digital Strategy for Schools 2015–2020*, available:
<https://www.gov.ie/pdf/?file=https://assets.gov.ie/25151/52d007db333c42f4a6ad542b5acca53a.pdf#page=null> [accessed 02 May 2023]
- Department of Education and Skills (2017a) *Education Policy Statement: 2017–2026*: Dublin: Government Publications, available:
<https://www.gov.ie/pdf/?file=https://assets.gov.ie/249002/3a904fe0-8fcf-4e69->

<https://www.gov.ie/pdf/?file=https://assets.gov.ie/249002/3a904fe0-8fcf-4e69-ab31-987babd41ccc.pdf#page=null> [accessed 02 May 2023]

Department of Education and Skill (2023, Recommendations on STEM and the Arts in Education, available: [https://assets.gov.ie/249003/0e73d94c-00ef-4fab-b929-4dc8d32d47df.pdf#page=null](https://assets.gov.ie/249003/0e73d94c-00ef-4fab-b929https://assets.gov.ie/249003/0e73d94c-00ef-4fab-b929-4dc8d32d47df.pdf#page=null) [accessed 18 Oct 2023]

Dienes, Z. (2014) "The Learning of Arithmetic—A Conceptual Guide." Routledge.

English, L.D. (2016) 'STEM education K-12: Perspectives on integration', *International Journal of STEM Education*, 3(1), 1–8.

Fernandez, C. (2002) Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education*, 53(5), 393-405

Fernandez, C., & Yoshida, M. (2004) *Lesson Study: A Japanese Approach to Improving Mathematics Teaching and Learning*. Mahwah, NJ: Lawrence Erlbaum Associates.

Finlay, L., & Gough, B. (Eds.). (2003) *Reflexivity: A Practical Guide for Researchers in Health and Social Sciences*. Wiley-Blackwell.

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: A stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(3), 185–189.

Gates, A.E., (2017) Benefits of a STEAM collaboration in Newark, New Jersey: Volcano simulation through a glass-making experience. *Journal of Geoscience Education*, 65(1), pp.4-11.

Ge, X., Ifenthaler, D., & Spector, J. (2015) Moving forward with STEAM education research. In X. Ge, D. Ifenthaler, & J. Spector (Eds.), *Emerging technologies for STEAM education. Educational communications and technology: Issues and innovations* (pp. 383–396). Springer.

Gomez, A., & Albrecht, B. (2013) True STEM education. *Technology and Engineering Teacher*, 73(4), 8

Goodgame, C. (2018) BeeBots and Tiny Tots. In E. Langran & J. Borup (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1179-1183). Washington, D.C., United States: Association for the Advancement of Computing in Education (AACE).

Grinnell, S. and Angal, S., (2016) Luminous lighting. *Science and Children*, 53(6), p.54.

- Gross, K. and Gross, S., (2016) Transformation: Constructivism, design thinking, and elementary STEAM. *Art Education*, 69(6), pp.36-43.
- Hall, T.E., Meyer, A., Ed. D, Rose, D.H. & ProQuest (Firm) (2012), *Universal design for learning in the classroom: practical applications*, Guilford Press, New York.
- Henrikson, D. (2014) 'Full STEAM Ahead: Creativity in Excellent STEM Teaching Practice.' *The STEAM Journal*, 1(2), 15.
- Herro, D. and Quigley, C., (2016) STEAM enacted: A case study of a middle school teacher implementing STEAM instructional practices. *Journal of Computers in Mathematics and Science Teaching*, 35(4), pp.319-342.
- Holden, M. (2023), "Exploring online lesson study as a vehicle for teacher collaborative professional learning", *International Journal for Lesson and Learning Studies*, Vol. 12 No. 2, pp. 179-193, available: <https://www.emerald.com/insight/content/doi/10.1108/IJLLS-01-2022-0012/full/html> accessed [01 May 2023]
- Hourigan, M. and Leavy, A. (2019) 'Learning from teaching: pre-service primary teachers' perceived learning from engaging in formal Lesson Study', *Irish Educational Studies*, 38(3), 283–308.
- Hourigan, M. and Leavy, A. (2020) 'Using integrated STEM to develop elementary students' statistical literacy', *Teaching Statistics*, 42, 77–86.
- Hourigan, M. & Leavy, A.M. (2021) 'The complexities of assuming the 'teacher of teachers' role during lesson study", *Professional development in education*, vol. ahead-of-print, no. ahead-of-print, pp. 1-14.
- Hourigan, M. & Leavy, A.M. (2023) 'Elementary teachers' experience of engaging with Teaching Through Problem Solving using Lesson Study", *Mathematics education research journal*, , pp. 1-27
- Hurling, M. & Speake Dwyer, J. (2018) *Designing Meaningful STEM Lessons*, NSTA Press.
- Jeon, M., Fakhrosseini, M., Barnes, J., Duford, Z., Zhang, R., Ryan, J., & Vasey, E. (2016). Making live theatre with multiple robots as actors: Bringing robots to rural schools to promote STEAM education for underserved students. *ACM/IEEE International Conference on Human-Robot Interaction*.

- Jho, H., Hong, O. and Song, J., (2016) An analysis of STEM/STEAM teacher education in Korea with a case study of two schools from a community of practice perspective. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(7), pp.1843-1862.
- Johnson, C. (2013) Conceptualizing integrated STEM education. *School Science and Mathematics*, 113(8), 367–368.
- Jolly, A., (2014) STEM vs. STEAM: Do the arts belong. *Education Week*, 18, p.16.
- Jolly, A. (2017) *STEM by Design: Strategies and Activities for Grades 4-8*. New York: Routledge.
- Kant, J., Burckhard, S. and Meyers, R., (2018) Engaging high school girls in Native American culturally responsive STEAM activities. *Journal of STEM Education*, 18(5).
- Keane, L. and Keane, M., (2016) STEAM by Design. *Design and Technology Education*, 21(1), pp.61-82.
- Kaneko, K., & Yamada, H. (2019). Job-sheet-based analytics regarding knowledge retention in digital fabrication education. *Proceedings - 2019 8th International Congress on Advanced Applied Informatics, IIAI-AAI 2019*, 234–239.
- Kelley, T. R. & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1), 1–11.
- Kelly, A. E., & Sloane, F. C. (2003). Educational research and the problems of practice. *Irish Educational Studies*, 22 (1), 29 – 40. <https://doi.org/10.1080/0332331030220106>.
- Land, M.H., (2013) Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, 20, pp.547-552.
- Lindeman, K.W. and Anderson, E.M. (2015) 'Using blocks to develop 21st century skills', *YC Young Children*, 70(1), 36–43.
- Liston, M. (2018) Designing Meaningful STEM Lessons, *Science*, 53 (4) pp 34-37.
- Leavy, A. M., Hourigan, M., & McMahon, A. (2010). Facilitating inquiry based learning in mathematics teacher education. In *Proceedings of SMEC 2010: Science and Mathematics Education Conference* . Dublin City University.

- Leavy, A., and Hourigan, M. (2016) 'Using lesson study to support knowledge development in initial teacher education: Insights from early number classrooms', *Teaching & Teacher Education*, 57, 161–175.
- Leavy, A. and Hourigan, M. (2018) 'Using lesson study to support the teaching of early number concepts: Examining the development of prospective teachers' specialized content knowledge', *Early Childhood Education Journal*, 46(1), 47–60.
- Leavy, A., Hourigan, M., Harmon, M., Treacy, M., and Fitzpatrick, M. (2023) Primary Mathematics Curriculum Consultation: Consultation with Children FINAL REPORT, Mary Immaculate College, Limerick.
- Lewis, C. (2002). *Lesson Study: A Handbook of Teacher-Led Instructional Change*, Research for Better Schools, Inc.
- Lewis, C. (2002) Does Lesson Study Have a Future in the United States? *Nagoya Journal of Education and Human Development*, 1, 1-23.
- Lewis, C., & Tsuchida, I. (1998) A Lesson is Like a Swiftly Flowing River: How Research Lessons Improve Japanese Education. *American Educator*, 22(4), 12-17, 50-52.
- Lloyd, M. & Chandra, V. (2020) "Teaching coding and computational thinking in primary classrooms : perceptions of Australian preservice teachers", *Curriculum perspectives*, vol. 40, no. 2, pp. 189-201.
- McClure, E., (2017) More than a foundation: Young children are capable STEM learners. *YC Young Children*, 72(5), pp.83-89.
- McClure, E., Guernsey, L., Clements, D., Bales, S., Nichols, J., Kendall-Taylor, N. and Levine, M., (2017) How to integrate STEM into early childhood education. *Science and Children*, 55(2), pp.8-10.
- Moomaw, S. (2013), *Teaching STEM in the early years: activities for integrating science, technology, engineering, and mathematics*, First edn, Redleaf Press, St. Paul, Minnesota.
- Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., & Roehrig, G. H. (2014) Implementation and integration of engineering in K-12 STEM education. In J. Strobel, S. Purzer, & M. Cardella (Eds.), *Engineering in precollege settings: Research into practice* (pp. 35–60). Rotterdam: Sense Publishers
- Morrin, A.M. and Liston, M., (2020) Engaging children with authentic STEAM learning experiences through design-based approaches. *Connect. Sci. Learn*, 2, p.202.

- Murphy, C., Venkat, H., Leahy, M., Broderick, N., Kelly, O., Butler, D., Harbison, L., Lawlor, C., & Naughton, Y. (2023). STEM Education: Curriculum & literature overview & Primary science education: Systematic literature review. Dublin: National Council for Curriculum and Assessment.
- National Council for Curriculum and Assessment (NCCA) (2009) Aistear: The Early Childhood Curriculum Framework. Dublin: NCCA.
- National Council for Curriculum and Assessment (2018). Primary Mathematics Curriculum: Draft Specification Junior Infants to Second Class, Dublin: National Council for Curriculum and Assessment.
- National Council for Curriculum and Assessment (2022) Arts Education. Available: <https://ncca.ie/en/primary/primary-developments/arts-education/> [accessed 01 May 2023]
- National Council for Curriculum and Assessment (2023) Updating Aistear Development Group. Available: <https://ncca.ie/en/early-childhood/early-childhood-educationhttps://ncca.ie/en/early-childhood/early-childhood-education-developments/updating-aistear/updating-aistear-development-group/developments/updating-aistear/updating-aistear-development-group/> [accessed 03 May 2023]
- National Council for Curriculum and Assessment (NCCA) (2023), Primary Curriculum Framework: For Primary and Special Schools, Dublin: National Council for Curriculum and Assessment.
- National Council for Curriculum and Assessment (NCCA) (2024) Draft Arts Education Specification: For primary and special schools, Dublin: National Council for Curriculum and Assessment.
- National Council for Curriculum and Assessment (NCCA) (2024), Draft Science, Technology and Engineering Education Specification: For primary and special schools, Dublin: National Council for Curriculum and Assessment.
- NGSS Lead States. (2013) Next generation science standards: For states, by states. Washington, DC: The National Academies Press.
- Ní Shúilleabháin, A. (2016) 'Developing mathematics teachers' pedagogical content knowledge in lesson study: Case study findings', International Journal for Lesson and Learning Studies, 5(3), 212–226.

- O'Donnell, S. (2018) Audit of the Content of Early Years and Primary Curricula in Eight Jurisdictions: Desk study for the National Council for Curriculum and Assessment (NCCA): Key findings synthesis: curriculum breadth, depth and organisation.
- O'Dwyer, A., Hourigan, M., Leavy, A.M. and Corry, E., (2023) 'I Have Seen STEM in Action and It's Quite Do-able!' The Impact of an Extended Professional Development Model on Teacher Efficacy in Primary STEM Education. *International Journal of Science and Mathematics Education*, pp.1-27.
- OECD. (2018). The future of education and skills: Education 2030, available: [https://www.oecd.org/education/2030/E2030%20Position%20Paper%20\(05.04.2018\).pdf](https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf) [accessed 26 Sep 2023]
- Ozkan, G. & Umdu Topsakal, U. (2021) "Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics", *Research in science & technological education*, vol. 39, no. 4, pp. 441-460.
- Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015) Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533-544.
- Partnership for 21st Century Skills (2009) A Framework for Twenty-First Century Learning, available: <https://www.battelleforkids.org/networks/p21/frameworks-resources>
- Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Sage Publications.
- Perignat, E. & Katz-Buonincontro, J. (2019) "STEAM in practice and research: An integrative literature review", *Thinking skills and creativity*, vol. 31, pp. 31-43.
- Piaget, J. (1973) *To understand is to invent: The future of education*. Grossman Publishers
- Quaresma, M., Winslow, C., Clivaz, S., da Ponte, J.P., Ní Shúilleabháin, A. & Takahashi, A., Ph. D (2018) *Mathematics lesson study around the World: theoretical and methodological issues*, Springer, Cham, Switzerland.
- Quigley, C.F., and D. Herro. (2016) Finding the Joy in the Unknown?: Implementation of STEAM Teaching Practices in Middle School Science and Math Classrooms. *Journal of Science Education and Technology* 25: 410–426.
- Resnick, M. (2017) *Lifelong Kindergarten: Cultivating Creativity through Projects, Passion, Peers, and Play*. Cambridge: MIT Press.

- Rice, K.J. (2020), Steam Education: Integrating the Arts into STEM to Create STEAM, The University of Nebraska - Lincoln.
- Rose, D., (2000) Universal design for learning. *Journal of Special Education Technology*, 15(4), pp.47-51.
- Sharapan, H. (2012) 'From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach', *YC Young Children*, 67(1), 36–40.
- Smith, G. (2014) 'An innovative model of professional development to enhance the teaching and learning of primary science in Irish schools', *Professional Development in Education*, 40(3), 467–487
- STEM Task Force Report. (2014) *Innovate: a blueprint for science, technology, engineering, and mathematics in California public education*. Dublin, California: Californians Dedicated to Education Foundation.
- Stohlmann, M., Moore, T. & Roehrig, G. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, 2(1), 28–34.
- Sung, J., Lee, J.Y. & Chun, H.Y. (2023), "Short-term effects of a classroom-based STEAM program using robotic kits on children in South Korea", *International Journal of STEM Education*, vol. 10, no. 1, pp. 26.
- Takahashi, A. (2005) 'Improving content and pedagogical knowledge through kyozaikenkyu', in Wang-Iverson, P. and Yoshida, M. (eds.) *Building Our Understanding of Lesson Study*. Philadelphia: Research for Better Schools, 101–110.
- Tanna, M. (2016) 'Goats, giants, and ... science? Teaching engineering concepts through fairy tales', *Children and Libraries*, 14(4), pp. 21–22.
- The Teaching Council (2020) 'Céim: Standards for Initial Teacher Education', available: <https://www.documentcloud.org/documents/21085106-ceim-standards-for-initial><https://www.documentcloud.org/documents/21085106-ceim-standards-for-initial-teacher-education-1> [accessed 25 Sep 2023]
- Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M. and Hellinckx, L., (2018) Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education*, 3(1), p.2.

- Tippett, C. and Milford, T. (2017) 'Findings from a pre-kindergarten classroom: Making the case for STEM in early childhood education', *International Journal of Science & Mathematics Education*, 15, 67–86.
- Trilling, B. and Fadel, C. (2009) *21st century skills: Learning for life in our times*. John Wiley & Sons.
- Tsupros, N., Kohler, R., & Hallinen, J. (2009) *STEM education: A project to identify the missing components*. Pennsylvania: Intermediate Unit, 1 and Carnegie Mellon.
- Vasquez, J.A., (2015) *STEM--Beyond the Acronym*. *Educational Leadership*, 72(4), pp.1015.
- Vasquez, J.A., Sneider, C.I. and Comer, M.W., (2013) *STEM lesson essentials, grades 3-8: Integrating science, technology, engineering, and mathematics* (pp. 58-76). Portsmouth, NH: Heinemann.
- Vrikki, M., Warwick, P., Vermunt, J.D., Mercer, N. and Van Halem, N. (2017) 'Teacher learning in the context of Lesson Study: A video-based analysis of teacher discussions', *Teaching and Teacher Education*, 61, 211–224.
- Yoshida, M. (1999). *Lesson study: A case study of a Japanese approach to improving instruction through school-based teacher development*. Unpublished doctoral dissertation, University of Chicago.

Appendices

Appendix A: Information Letter to the Board of Management



Board of Management Information Sheet

Dear Members of the Board,

I am currently pursuing a course of studies leading to a masters degree in education from Mary Immaculate College. With this in mind I now seek the consent of the Board to carry out some research in the school. I would be grateful for consent and for your support.

In this study I aim to investigate the characteristics of a good STEAM intervention in senior infants through use of lesson study. Lesson study is a model of professional development which supports teacher learning through collaboration. It consists of a cycle of phases, where a group of teachers work together to plan, conduct, observe and reflect on a research lesson. My data collection methods will include audio recording of conversations between the teachers and I, as well as keeping observational notes relevant to my research. I will seek consent from the parents for their children to become involved in the research.

I guarantee confidentiality around any information collected. I will only report information that is within the public domain and within the law. I will not reveal anything of a personal or comprising nature. There will be total confidentiality of all names and the school will also not be named. You are free to withdraw from the research at any time without giving a reason and without consequence. Data collection would be terminated at this point.

If you have any questions about this project, contact Emer Quane, 17214424@micstudent.mic.ul.ie. This research study has received Ethics approval from the Mary Immaculate College Research Ethics Committee (MIREC) reference number (A22 - 074). If you have concerns about this study and wish to contact an independent authority, you may contact: Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie.

Thank you very much for you time,
Emer Quane

Appendix B: Letter of Consent to the Board of Management



Consent Form

To whom it may concern,

Emer Quane has the permission of this Board of Management to carry out a lesson study research project in this school, as described above. This consent includes the participation in a lesson study process working with two other teachers in the school, and the collection of necessary data.

Signed: _____

Chairperson of the Board of Management



Principal Information Letter

School name,
School address, -
- ----- 2022.

Dear Principal,

As part of my Masters research programme, I am undertaking some research on the characteristics of a good STEAM intervention in senior infants through use of lesson study. I would be grateful if you would grant me consent to conduct this research.

I intend to invite my teaching colleagues to participate in a lesson study. Lesson study is a model of professional development which supports teacher learning through collaboration. It consists of a cycle of phases, where a group of teachers work together to plan, conduct, observe and reflect on a research lesson. I will seek consent from the parents for their children to become involved in the research. I guarantee confidentiality around any information collected, and promise not to reveal the names of the school, colleagues or children in the research report. My data collection methods will include audio recording of conversations between the teachers and me, as well as observational notes relevant to my research. You are free to withdraw from the research at any time without giving a reason and without consequence. Data collection would be terminated at this point.

I enclose two copies of this letter, one for your files and one to be returned to me for retention in my files. I would appreciate it, therefore, if you would sign the consent slip below and return it to me at your earliest convenience

If you have any questions about this project, contact Emer Quane, 17214424@micstudent.mic.ul.ie. This research study has received Ethics approval from the Mary Immaculate College Research Ethics Committee (MIREC) reference number (A22 - 074). If you have concerns about this study and wish to contact an independent authority, you may contact: Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie.

Yours sincerely,

Emer Quane

Appendix D: Letter of Consent to the Principal



Principal Consent Form

To Whom It May Concern:

I, principal of school, give permission to Emer Quane to undertake research in the above-named school. This consent includes the participation in a lesson study process working with two other teachers in the school, and the collection of necessary data.

Signed: _____

Appendix E: Information Letter to the Teachers

Teacher Information Letter

Dear Teacher,

As part of my Masters research programme, I am undertaking some research on the characteristics of a good STEAM intervention in senior infants through use of lesson study. I intend to invite you, my teaching colleagues, to collaborate with me in critical evaluations of the study. I would be grateful if you would grant me consent to partake in this research.

Participation in Lesson Study will involve the research and design of lessons in STEAM (science, technology, engineering, arts and mathematics). There will be two teachers involved. Once a lesson has been designed and evaluated by the teachers involved and I, one teacher will teach the lesson as an opportunity to evaluate the adequacy of the lesson in the live classroom setting, the other teacher will observe. The main focus of the research is on the teaching processes rather than on the children. After observation of the lesson, reflection and discussion will follow and a revised lesson will be constructed. Both teachers and the researcher will be involved in this discussion. The lesson will then be retaught by the teacher who observed the first lesson, to a different cohort of infants, with the other teacher now observing. Input will be required from you at all stages of the lesson study. My data collection methods will include audio recording of conversations, as well as the keeping of observational notes. I will seek consent from the parents for their children to become involved in the research. I guarantee confidentiality around any information collected, and promise not to reveal the names of the school, colleagues or children in the research report.

I enclose two copies of this letter, one for your files and one to be returned to me for retention in my files. I would appreciate it, therefore, if you would sign the consent slip below and return it to me at your earliest convenience. You are free to withdraw from the research at any time without giving a reason and without consequence.

If you have any questions about this project, contact Emer Quane, 17214424@micstudent.mic.ul.ie. This research study has received Ethics approval from the Mary Immaculate College Research Ethics Committee (MIREC) reference number (A22 - 074). If you have concerns about this study and wish to contact an independent authority, you may contact: Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick.

Telephone: 061-204980 / E-mail: mirec@mic.ul.ie.

Yours sincerely,
Emer Quane



Appendix F: Class Teacher Consent Form



Class Teacher Consent Form

- ❖ I have read and understood the Teacher Information Letter
- ❖ I understand what the project is about
- ❖ I know that my participation is voluntary and that I can withdraw from the project at any stage without giving any reason and without consequence
- ❖ I am aware that results will be kept confidential
- ❖ I have read this form completely, I am 18 years of age or older and am happy to take part in the study on Lesson Study and STEAM

Signature: _____

Date: _____



Parent/ Guardian Information Letter

Dear Parent/Guardian,

As part of my Masters research programme, I am undertaking some research on STEAM (science, technology, engineering, arts and mathematics) education through lesson study. Once a lesson has been designed and evaluated, teachers will teach the lesson as an opportunity to evaluate the adequacy of the lesson in the live classroom setting. The main focus of the research is on the teaching processes rather than on the children. Your child's class has been selected for this project.

It is our hope that all children will benefit from participating in the research. The lessons we will teach focus on important mathematical, scientific and arts concepts in the Irish Primary School Curriculum. In the writing up of this report I will observe the strictest confidentiality – neither the school nor the children will be named.

Optimum participation is important in order to represent STEAM teaching in a real classroom. Therefore we would be grateful for your support in this project. You have the right to refuse consent for your child to co-operate. Should you wish to do so, I guarantee that your refusal will not in any way affect my relationship with you or your child.

If you have any questions about this project, contact Emer Quane, 17214424@micstudent.mic.ul.ie. This research study has received Ethics approval from the Mary Immaculate College Research Ethics Committee (MIREC) reference number (A22 - 074). If you have concerns about this study and wish to contact an independent authority, you may contact: Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick. Telephone: 061-204980 / E-mail: mirec@mic.ul.ie.

Please complete the consent form on the following page and return it to your child's teacher. Retain this information page for your own records. Thank you for your cooperation.

Yours sincerely,

Appendix H: Parent/ Guardian Consent Form

Parent/ Guardian Consent Form

Permission form for your child to take part in 'Lesson Study'

I give permission for my child _____ (insert name) to collaborate in this project.

I do not give permission for my child, _____ (insert name) to collaborate in this project.

Signature of Parent or Guardian: _____

Date: _____

Appendix I: Assent Form for Children

Assent Form for Children

I would like to find out what is important to you about learning in this school so I can tell other adults about it. Is this ok with you? If you want to stop at any time please just ask me and we will stop. If you would like to do this activity with me you can tick the smiley face (read out by the researcher).



Name: _____

Appendix J: Semi - Structured Interview Questions for Teachers

Initial Interview

Do you know what STEAM is?

What would be your level of confidence in teaching STEAM?

How important is STEAM? Do you think it's necessary?

Do you think STEAM should be taught to 5–7-year-olds?

Have you any concerns about implementing STEAM?

What do you think are important traits of professional development?

Have you heard of lesson study? Do you know what it is?

Midway Interview

Have your perceptions of STEAM changed?

What have you learned?

Is there anything that has surprised you?

What are your thoughts on lesson study?

Were you happy I taught first?

What does STEAM mean to you now?

Is there anything that would help you going forward?

Which lesson did you most enjoy, or think was the best lesson? Why?

Which was your least favourite lesson so far? Why?

Final Interview

How would you now define STEAM education?

What was your favourite lesson? Why?

What was your least favourite lesson? Why?

What pedagogies from the lessons do you feel worked best?

What has your involvement in this project had on your perception of teaching STEAM?

Have you observed any changes in your pupils' attitudes to STEAM disciplines/ STEAM since this project began?

We changed our practice in our STEAM lessons, how did you find changing your practice?

What helped you make these changes?

What advice would you give other teachers regarding the teaching of STEAM?

Finally, please share any additional thoughts, feelings, discoveries, and insights from your engagement with lesson study in regard to STEAM, your teaching practices, collaboration with others, or additional input you feel is relevant to this discussion.

What has your experience of lesson study been over the last months?

What aspects of lesson study did you find most useful?

What did you gain most from your involvement in the project?

Did your teaching change as a result of lesson study and if so in what ways? What has helped you make these changes?

Appendix K: Research Lesson 1 - Pilot Cycle

Lesson 1: Bobby's BEEutiful New Home

STEAM Challenge: Build Bobby and his fellow bees a new home

Class: Senior Infants

Time: 45 minutes

Strand: Visual Arts - Construction

Engineering - EDP

Strand Unit: Visual Arts - Making Constructions, Looking and Responding

Engineering -

Lesson: *Construct a bee house using recycled materials*

Curricular Objectives:

The child will be enabled to:

- ❖ Explore and experiment with the properties and characteristics of materials in making structures.
- ❖ Look at and talk about spatial arrangements and balance in collections of objects in photographs of natural and built structures
- ❖ Look at and talk about his/her work and the work of other children

The child will be enabled to:

- ❖ Develop their engineering skills: Spatial, Critical Thinking, Innovative, Problem Solving, Communication and Collaboration.

Materials/ Resources:

Bee puppet, Powerpoint, Construction pack: glue, scissors, cardboard, straws, paper cups, playdough, paper, sticks. Tinfoil.

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Introduce Bobby and the task to the class through a story. ‘This is my friend Bobby. He is very excited to meet ye but first Bobby has a story to tell. Bobby lives in the park [show image]. It’s beautiful with lots of trees and flowers. Bobby lived in a hive in the tree with her worker friends. One day there was a terrible storm, all the leaves on the trees and flowers were blown away. In this storm Bobby’s home was destroyed, wasn’t it? [puppet nods]. Is everybody really sad for Bobby? Bobby need a new home, and wants to make sure it will survive any storm! He was hoping ye would help him build his new home.. Hands up if ye can help.</p> <p>Tell the students that in groups we are going to make different Bee houses for Bobby and note that they need to be strong and sturdy.</p>	<p>Yes I could No I don’t know how I’m not sure</p>	<p>Give praise to students who are eager to help.</p> <p>Encourage and reassure those who are not as confident.</p> <p>Might need to explain what sturdy means. <i>Strongly or solidly built.</i></p>	<p>Are they engaged?</p> <p>The teacher will listen out for how the children are feeling about the task.</p>

Development 1

<p>discussing their designs.</p>	<p>X will make it strong I need X</p>	<p>Question the children on their constructions. 'What's this?' 'Why are you putting that there?'</p>	<p>How well are they able to do it?</p>
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	This is where Bobby can sleep/ enter etc.	Encourage all children to engage in the building.	
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Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p><u>Testing</u> Invite groups up to the wind station [hairdryer] to test their bee houses. Start at low setting, move to high if it survives low.</p> <p>Discuss the strengths and weaknesses of their constructions and discuss what changes they could make to improve their bee house.</p> <p>Use prompt questions to stimulate further learning. <i>‘ What did you notice ’</i> <i>‘How do you think you might fix that?’</i> <i>‘What did you do to make your house so strong?’</i></p> <p><u>Revise and Redesign</u> Students return to their workspace and attempt to improve their constructions following the testing stage findings.</p> <p>Groups have the opportunity to retest their constructions. Use</p>	<p>It fell down. It stayed up. I could __ to make it stronger. I don’t know</p> <p>It fell down. It stayed up.</p>	<p>Offer children the option of using low/high setting. Count down with them.</p> <p>Can you think of anything else you could use? Praise children for their work.</p> <p>Explain how we learn from our mistakes.</p> <p>Link Bobby back in to praise children on their</p>	<p>How do students react to failure?</p> <p>Are they able to discuss their constructions?</p> <p>Do the students have solutions to improve their construction and make it stronger?</p> <p>Are they still motivated?</p>

<p>prompt questions to stimulate further</p>	<p>I don't know To make it stronger I added more glue/</p>	<p>buildings and changes, and to explain what</p>	
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<p>learning. <i>'What did you do to make sure it was strong enough to not blow away?'</i></p> <p><i>'What didn't work last time? What did ye do to improve it?'</i></p>	<p>weight etc. It worked this time because I added X.</p> <p>Last time we didn't have enough of glue/weight.</p>	<p>they did. <i>'Bobby wants to know how you built your house?'</i></p>	<p>Can students verbally explain what made their constructions stronger?</p>
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Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p><u>Whole Class Discussion</u></p> <p>Bobby whispers into the teacher's ear. The teacher tells the class <i>'Bobby has just told me he is so impressed with all of your constructions. He especially loved how ye looked at yere first designs and went back again to make them even better!'</i></p> <p><i>Can anyone tell me some things they did that made their bee house strong? Was it a good idea to draw a blueprint first? How did you feel about going back and redesigning your construction?</i></p>	<p>Yay Aww</p> <p>We added more glue. We added more weight. We moved X from there to here etc. Yes No I liked it I didn't like it I don't know</p>	<p>Reiterate the importance of planning, testing and redesigning.</p>	<p>They will be able to discuss their builds with reasons.</p> <p>They can give reasons for use of different materials.</p>

Appendix K1: Research Lesson 2 - Pilot Cycle

Revised Lesson Plan Lesson 1: Bobby's BEEutiful New Home

STEAM Challenge: **Build Bobby a New Home**

Class: Senior Infants

Time: 45 minutes

Strand: Visual Arts - Construction

Engineering - EDP

Strand Unit: Visual Arts - Making Constructions, Looking and Responding

Engineering

Lesson: *Construct a bee house using recycled materials*

Curricular Objectives:

The child will be enabled to:

- ❖ Explore and experiment with the properties and characteristics of materials in making structures.
- ❖ Look at and talk about spatial arrangements and balance in collections of objects in photographs of natural and built structures
- ❖ Look at and talk about his/her work and the work of other children

The child will be enabled to:

- ❖ Develop their engineering skills: Spatial, Critical Thinking, Innovative, Problem Solving, Communication and Collaboration.

Materials/ Resources:

Bee puppet, Powerpoint, Construction pack: glue, scissors, cardboard, straws, paper cups, sticks, tinfoil, **pencils, bubblewrap, foam. (playdough and paper removed)**

Introduction (5 mins)

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Introduce Bobby and the task to the class through a story. ‘This is my friend Bobby. He is very excited to meet ye but first Bobby has a story to tell. Bobby lives in the park [show image]. It’s beautiful with lots of trees and flowers. Bobby lived in a hive in the tree with her worker friends. One day there was a terrible storm, all the leaves on the trees and flowers were blown away. In this storm Bobby’s home was destroyed, wasn’t it? [puppet nods]. Is everybody really sad for Bobby? Bobby need a new home, and wants to make sure it will survive any storm! He was hoping ye would help him build his new home.. Hands up if ye can help.</p> <p>Tell the students that in groups we are going to make different Bee houses for Bobby and note that they need to be strong and sturdy.</p>	<p>Yes I could No I don’t know how I’m not sure</p>	<p>Give praise to students who are eager to help.</p> <p>Encourage and reassure those who are not as confident.</p> <p>Might need to explain what sturdy means. <i>Strongly or solidly built.</i></p>	<p>Are they engaged?</p> <p>The teacher will listen out for how the children are feeling about the task.</p>

Development 1 (10 mins)

<u>Learning</u>	<u>Expected Student</u>	<u>Teacher Response</u>	<u>Evaluation</u>
<p><u>Activities and Questions</u></p> <p><u>Blueprint</u> Children are divided into groups of 3.</p> <p><i>Before we start our constructions is there anything you think we should do?</i>[make a plan]</p> <p>Show the class photographs of structures discussing balance, strength. (more photos added to PP)</p> <p>Show the class an example of a blueprint on the board. Explain that a blueprint is 'drawing a plan for the house'.</p> <p>Hand out the materials. Tell the children to draw a blueprint for the house. Encourage children to think of the materials they have when drawing their blueprint.</p> <p>Circulate the room discussing with each group what will make theirs strong.</p> <p><u>Construction</u> Children begin designing their constructions in their groups.</p>	<p><u>Reactions</u></p> <p>Make a plan Talk about it Look at what we have</p> <p>X will give it support/make it strong I don't know</p>	<p><u>& Things to Remember</u></p> <p>All great ideas. Planning is really important as it helps you think about what you're making and what you need.</p> <p>Use visual timer</p> <p>Remind the students to think about what made the structures in the powerpoint strong when designing their blueprint.</p>	<p>Do the children have previous knowledge of blueprints/ planning?</p> <p>Can the children recognise what aspects of the buildings in the PP that make them strong?</p> <p>Can the children plan aspects to make their own constructions strong?</p>

<p>Teacher moves around the room observing and discussing their designs.</p>	<p>X will make it strong I need X This is where Bobby can sleep/ enter etc.</p>	<p>Question the children on their constructions. ‘What’s this?’ ‘Why are you putting that there?’ Encourage all children to engage in the building.</p>	<p>Do the children understand what they have to do? How well are they able to do it?</p>
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Development 2 (20 mins)

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>Testing Invite groups up to the wind station [hairdryer] to test their bee houses. Start at a low setting, move to high if it survives low.</p> <p>Discuss the strengths and weaknesses of their constructions and discuss what changes they could make to improve their bee house.</p> <p>Use prompt questions to stimulate further learning. <i>‘ What did you notice ’</i></p> <p><i>‘How do you think you might fix that?’</i></p> <p><i>‘What did you do to make your house so strong?’</i></p>	<p>It fell down. It stayed up. I could __ to make it stronger. I don’t know</p>	<p>Offer children the option of using low/high setting. Count down with them.</p> <p>Can you think of anything else you could use? Praise children for their work.</p>	<p>How do students react to failure?</p> <p>Are they able to discuss their constructions?</p>
<p><u>Revise and Redesign</u> Students return to their workspace and attempt to improve their constructions following the testing stage findings.</p> <p>Groups have the opportunity to retest their constructions. Use prompt questions to stimulate further learning.</p>	<p>It fell down. It stayed up. I don’t know To make it stronger I added more glue/ weight etc.</p>	<p>Explain how we learn from our mistakes.</p> <p>Link Bobby back in to praise children on their buildings and changes, and to explain what they did.</p>	<p>Do the students have solutions to improve their construction and make it stronger?</p> <p>Are they still motivated?</p> <p>Can students verbally explain what made</p>

<p><i>'What did you do to make sure it was strong enough to not blow away?'</i></p> <p><i>'What didn't work last time? What did ye do to improve it?'</i></p>	<p>It worked this time because I added X.</p> <p>Last time we didn't have enough of glue/weight.</p>	<p><i>'Bobby wants to know how you built your house?'</i></p>	<p>their constructions stronger?</p>
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Conclusion (5 minutes)

<p><u>Learning Activities and Questions</u></p>	<p><u>Expected Student Reactions</u></p>	<p><u>Teacher Response & Things to Remember</u></p>	<p><u>Evaluation</u></p>
<p><u>Whole Class Discussion</u></p> <p>Bobby whispers into the teacher's ear. The teacher tells the class <i>'Bobby has just told me he is so impressed with all of your constructions. He especially loved how ye looked at yere first designs and went back again to make them even better!'</i></p> <p><i>Can anyone tell me some things they did that made their bee house strong? Was it a good idea to draw a blueprint first? How did you feel about going back and redesigning your construction?</i></p>	<p>Yay Aww</p> <p>We added more glue. We added more weight. We moved X from there to here etc. Yes No I liked it I didn't like it I don't know</p>	<p>Reiterate the importance of planning, testing and redesigning.</p>	<p>They will be able to discuss their builds with reasons.</p> <p>They can give reasons for use of different materials.</p>

Appendix K2: Lesson 1 Powerpoint

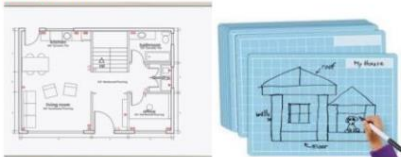
**Bobby's BEEutiful
New Home**



Building Structures



Blueprint



Appendix L: Research Lesson 1 - Cycle 2

Lesson 2: BeeBot Pollination

STEAM Challenge: Help Bobby pollinate some flowers

Class: Senior Infants

Time: 45 minutes

Strand: Science - Living Things

Technology

Strand Unit: Science - Plants and Animals

Technology - Coding

Lesson: *Using Beebots to Pollinate Flowers*

Curricular Objectives:

The child will be enabled to:

- ❖ Recognise and identify the external parts of living things.
- ❖ Observe, discuss and identify a variety of plants and animals in different habitats in the immediate environment.
- ❖ Become aware that animals and plants undergo seasonal change in behaviour

The child will be enabled to:

- ❖ Use BeeBot commands; forward, backward, left, right, go.
- ❖ Develop 21st century skills: counting, sequencing, problem solving, estimating, directionality and vocabulary.

Materials/ Resources:

Bee puppet, BeeBots, PP, coding cards, mats, bee headband

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Briefly refer to bee house making activity.</p> <p>Tell them that Bobby the Bee is back.</p> <p>Show the class a picture of bees pollinating and ask does anyone know what is happening in this picture?</p>	<p>Playing on the flowers Getting nectar I don't know</p>	<p>Great answers! Has anyone heard of pollination?</p>	<p>Can the children recall the previous lesson?</p> <p>Are they motivated for this lesson?</p> <p>Do they have any knowledge on pollination? Watch out for any misconceptions that need to be later addressed.</p>

Development 1

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Set focus question ‘Why do the flowers need help from the bee?’</p> <p>Show video https://www.youtube.com/watch?v=zy3r1zlCIU [0.13 - 2.30]</p> <p>Discuss video and explain that bees collect pollen when they land on flowers as it attaches to hairs on their legs. When they land on a new flower they drop pollen from previous flowers, which pollinates the flower and helps</p>	<p>Because they cant move I don’t know</p>	<p>Yes! Flowers need Bees to help them as flowers can’t move themselves</p>	<p>Do they grasp the concept of pollination?</p> <p>Address any misconceptions.</p>
<p>flowers to grow. In doing so bees also collect nectar from flowers which they can use to make honey.</p> <p>Powerpoint on the external parts of flowers and bees.</p>			<p>Can they label any parts of the flower/ bee at this point?</p>

Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Look at PP with different flowers - discuss colour.</p> <p>Divide children into groups of 3. Distribute blank beebot mats. Tell the children to pick a square each on the mat and draw a flower.</p>	<p>I like that flower I don't like that flower I prefer that flower than that flower</p>	<p>Note how bees are attracted to colour.</p>	<p>Do they draw colourful flowers? Do they include petals/ stem/ leaves?</p>

Development 3

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Invite one child up to the top of the classroom. Give them the bee headband and blindfold. Place flower images around the room. Ask the class to direct the student from flower to flower to pollinate.</p> <p>Tell the children they are going to use the beebots to pollinate some flowers.</p>	<p>Go left/ right/ straight Turn around Stop Go this way</p>	<p>Use hands to reiterate left and right</p>	<p>Does acting it out help reinforce directions and understanding?</p> <p>Are they able to use</p>

<p>Demonstrate how the beebot works the same as the directions they just used.</p> <p>Children return to their mats and try get their beebot from flower to flower.</p>			the beebots?
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Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Whole Class Discussion to recap.</p> <p>What is pollination? Why do flowers need bees? What directions can you give the beebots? How did you find using the beebots?</p>	<p>Pollination is moving pollen from one flower to another so it can grow.</p> <p>I don't know. To move the pollen. Left, right, forward, stop. Easy. Hard. Not hard but not easy.</p>		<p>Can they explain what pollination is? Can they talk about the parts of a flower and bee? Could they pollinate the flowers?</p>

Appendix L1: Research Lesson 2 - Cycle 2

Revised Lesson Plan Lesson 2: BeeBot Pollination

STEAM Challenge: Help Bobby pollinate some flowers

Class: Senior Infants

Time: 45 minutes

Strand: Science - Living Things

Technology -

Strand Unit: Science - Plants and Animals

Technology - Coding

Lesson: *Using Beebots to Pollinate Flowers*

Curricular Objectives:

The child will be enabled to:

- ~~❖ Recognise and identify the external parts of living things.~~
- ❖ Observe, discuss and identify a variety of plants and animals in different habitats in the immediate environment.
- ❖ Become aware that animals and plants undergo seasonal change in behaviour

The child will be enabled to:

- ❖ Use BeeBot commands; forward, backward, left, right, go.
- ❖ Develop 21st century skills: counting, sequencing, problem solving, estimating, directionality and vocabulary.

Materials/ Resources:

Bee puppet, BeeBots, PP, mats, bee headband, ~~bee puppet, coding cards, square paper sheets~~

Introduction (5mins)

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Briefly refer to bee house making activity.</p> <p>Tell them that Bobby the Bee is back.</p> <p>Show the class a picture of bees pollinating and ask does anyone know what is happening in this picture?</p>	<p>Playing on the flowers Getting nectar I don't know</p>	<p>Great answers! Has anyone heard of pollination?</p>	<p>Can the children recall the previous lesson?</p> <p>Are they motivated for this lesson?</p> <p>Do they have any knowledge on pollination? Watch out for any misconceptions that need to be later addressed.</p>

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Set focus question ‘Why do the flowers need help from the bee?’</p> <p>Show video https://www.youtube.com/watch?v=zy3r1zlCIU [0.13 - 2.30]</p> <p>Discuss video and explain that bees collect pollen when they land on flowers as it attaches to hairs on their legs. When they land on a new flower they drop pollen from previous flowers, which pollinates the flower and helps</p> <p>flowers to grow. In doing so bees also collect nectar from flowers which they can use to make honey.</p> <p>Powerpoint on the external parts of flowers and bees. Children have the chance to fill in the labels before they are revealed.</p>	<p>Because they cant move I don’t know</p>	<p>Yes! Flowers need Bees to help them as flowers can’t move themselves</p>	<p>Do they grasp the concept of pollination?</p> <p>Address any misconceptions.</p> <p>Can they label any parts of the flower/ bee at this point?</p>

Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Look at PP with different flowers - discuss colour.</p> <p>Children each draw a flower on a small square of paper.</p> <p>Divide children into groups of 3. Distribute blank beebot mats.</p> <p>Children each place their flowers on different squares.</p>	<p>I like that flower I don't like that flower I prefer that flower than that flower</p>	<p>Note how bees are attracted to colour, especially purple.</p> <p>Encourage children to not place flowers beside each other.</p>	<p>Do they draw colourful flowers? Do they include petals/ stem/ leaves?</p>

Development 3

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Invite one child up to the top of the classroom. Give them the bee headband and blindfold. Explain they can go forward (X) 1=</p>	<p>Go left/ right/ straight Turn around Stop Go this way</p>	<p>Use hands to reiterate left and right</p>	<p>Does acting it out help reinforce directions and understanding?</p>

<p>1 step, backward same, turn left, right. Others must direct them around the room to different things eg. teacher's desk, door etc. Place flower images around the room. Ask the class to direct the student from flower to flower to pollinate.</p> <p>Tell the children they are going to use the beebots to 'pollinate' some flowers. Demonstrate how the beebot works the same as the directions they just used. Now also explain that each time the bee stops you MUST press X/ clear as the bees remembers everything before.</p> <p>Children return to their mats and try get their beebot from flower to flower.</p>			<p>Are they able to use the beebots?</p>
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Conclusion

<p><u>Learning Activities and Questions</u></p>	<p><u>Expected Student Reactions</u></p>	<p><u>Teacher Response & Things to Remember</u></p>	<p><u>Evaluation</u></p>
<p>Whole Class Discussion to recap.</p> <p>What is pollination? Why do flowers need bees? What directions can you give the beebots? How did you find using the beebots?</p>	<p>Pollination is moving pollen from one flower to another so it can grow.</p> <p>I don't know. To move the pollen. Left, right, forward, stop. Easy. Hard. Not hard but not easy.</p>		<p>Can they explain what pollination is? Can they talk about the parts of a flower and bee? Could they pollinate the flowers?</p>

Appendix L2: Lesson 2 Powerpoint

BeeBot Pollination



Pollination

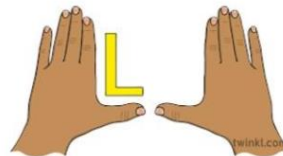
https://www.youtube.com/watch?v=zy3r1zIC_IU



Types of Flowers



Beebot Codes



Appendix M: Research Lesson 1 - Cycle 3

Lesson 3: Flower Planting with Bobby

STEAM Challenge: Design and plant some new flowers in Bobby's Garden to attract some new friends for Bobby

Class: Senior Infants

Time: 45 minutes

Strand: Science - Energy and Forces

Art - Paint and Colour

Strand Unit: Science - Light

Art - Painting

Lesson: *Design flowers and plant (place) them in a play garden where they will best grow.*

Curricular Objectives:

The child will be enabled to:

- ❖ Observe colours in the local environment
- ❖ Discuss differences between day and night, light and shade
- ❖ Explore dark and bright colours.

The child will be enabled to:

- ❖ Discover colour in the visual environment to help develop sensitivity to colour.
- ❖ Discover colour, pattern and rhythm in colourful objects.

Materials/ Resources:

Powerpoint, Bee puppet, bun cases (big and small), crayons, glue, park mats, blue tac

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Briefly refer to previous lesson on pollination. Tell the kids Bobby is back and needs their help again</p> <p>‘Hi kids, I’m back again. I must admit I’ve been feeling a little bit lonely recently. You know how I live in the park? Well there aren’t many other bees around the park for me to hang out with sooo I was hoping ye could help bring some new bees to my park?’</p> <p>Teacher interrupts and asks question; Does anyone have any idea how we could attract bees to the park? What do bees like?</p>	<p>Yes! No I can’t I don’t know how</p> <p>Build them bee houses Plant flowers I don’t know</p>	<p>Interesting ideas! Explain how bees love flowers and are attracted to them.</p>	<p>Can they recall information about pollination from the previous lesson?</p> <p>Is the puppet still an effective stimulus?</p> <p>Have they informed ideas already?</p>

Development 1

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Show powerpoint and discuss colours and patterns in flowers.</p> <p>Dark vs Bright - How does each picture make you feel?</p>	<p>Happy/ sad I don't know Nothing</p>	<p>Red makes me feel... etc.</p>	<p>Can they connect feelings and colours appropriately?</p>
<p>Tell the children it is now time to make some flowers using bun cases. Remind them the flowers need to be bright/ have a pattern.</p> <p>Children first make cuts on the cases for petals. They then design them as they wish.</p>		<p>Fun fact: they especially like purple!</p> <p>Circulate and observe childrens designs. Assist children who need help with cutting.</p>	<p>Do they make colourful flowers with bright patterns?</p>

Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Teacher says ‘Now that we have our flowers, where should we plant them? Think about what do flowers need to grow?’</p> <p>Do we always have sunlight?</p> <p>Children are given parks with various light obstacles such as trees/ buildings etc. They must decide where is best to plant their flowers and explain why they have chosen that spot.</p>	<p>Water Food The sun I don’t know</p> <p>Yes No</p> <p>I will plant my flower here because... I didn’t plant my flower here because...</p>	<p>Sunlight, water and nutrients from the soil</p> <p>Talk about night vs day</p> <p>Praise explanations</p>	<p>Do they have knowledge already on planting?</p> <p>Can they recognise the differences between day/night?</p> <p>Do they plant the flowers in good areas? Can they justify their reasons using knowledge from the lesson?</p>

Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>

<p>Show and Tell Each group comes up to the top of the classroom to showcase their flowers and planting. (Use visualiser so class can see)</p> <p>The rest of the class have the opportunity to agree/ disagree with each groups planting choices.</p>	<p>I think it was a good idea that they planted their flowers their because ... If I was planting my flower in that park I would've planted it X instead</p>	<p>During this time informally assess the children's learning through their planting and reasoning.</p>	<p>Can each group justify their planting choices?</p> <p>Do others have a reasonable input of changes in other groups' choices?</p> <p>Are the flowers colourful/ have patterns?</p>
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Appendix M1: Research Lesson 2 - Cycle 3

Revised Lesson Plan Lesson 3 : Flower Planting with Bobby

STEAM Challenge: Design and plant some new flowers in Bobby's Garden to attract some new friends for Bobby

Class: Senior Infants

Time: 45 minutes

Strand: Science - Energy and Forces

Art - Paint and Colour

Strand Unit: Science - Light

Art - Painting

Lesson: *Design flowers and plant (place) them in a play garden where they will best grow.*

Curricular Objectives:

The child will be enabled to:

- ❖ Observe colours in the local environment
- ❖ Discuss differences between day and night, light and shade

- ❖ Explore dark and bright colours.

The child will be enabled to:

- ❖ Discover colour in the visual environment to help develop sensitivity to colour.
- ❖ Discover colour, pattern and rhythm in colourful objects.

Materials/ Resources:

Powerpoint, Bee puppet, bun cases (big and small), crayons, glue, park mats, blue tac

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Briefly refer to previous lesson on pollination. Tell the kids Bobby is back and needs their help again</p> <p>‘Hi kids, I’m back again. I must admit I’ve been feeling a little bit lonely recently. You know how I live in the park? Well there aren’t many other bees around the park for me to hang out with sooo I was hoping ye could help bring some new bees to my park?’</p> <p>Teacher interrupts and asks question; Does anyone have any idea how we could attract bees to the park? What do bees like?</p>	<p>Yes! No I can’t I don’t know how</p> <p>Build them bee houses Plant flowers I don’t know</p>	<p>Interesting ideas! Explain how bees love flowers and are attracted to them.</p>	<p>Can they recall information about pollination from the previous lesson?</p> <p>Is the puppet still an effective stimulus?</p> <p>Have they informed ideas already?</p>

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Development 1

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Show powerpoint and discuss colours and patterns in flowers.</p>			

<p>Dark vs Bright - How does each picture make you feel?</p> <p>Tell the children it is now time to make some flowers using bun cases. Remind them the flowers need to be bright/ have a pattern.</p> <p>Show on powerpoint images of the art activity for visual support. Give children 2 big bun cases and 1 small. Children first make cuts on the cases for petals. They then design them as they wish.</p>	<p>Happy/ sad I don't know Nothing</p>	<p>Red makes me feel... etc.</p> <p>Fun fact: they especially like purple!</p> <p>Circulate and observe childrens designs. Assist children who need help with cutting.</p> <p>Use visual timer for art activity.</p>	<p>Can they connect feelings and colours appropriately?</p> <p>Do they make colourful flowers with bright patterns?</p>
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Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Teacher says ‘Now that we have our flowers, where should we plant them? Think about what do flowers need to grow?’</p> <p>Do we always have sunlight? Explain that the sun rises in the east and sets in the west</p> <p>Children are given parks with various light obstacles such as trees/ buildings etc. Sunrise and sunset images included on the parks.They must</p>	<p>Water Food The sun I don’t know</p> <p>Yes No</p> <p>I will plant my flower here because... I didn’t plant my flower here because...</p>	<p>Sunlight, water and nutrients from the soil</p> <p>Talk about night vs day</p> <p>Praise explanations</p>	<p>Do they have knowledge already on planting?</p> <p>Can they recognise the differences between day/night?</p> <p>Do they plant the flowers in good areas? Can they justify their reasons using knowledge from the lesson?</p>
<p>decide where is best to plant their flowers and explain why they have chosen that spot.</p>			

Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Show and Tell Each group comes up to the top of the classroom to showcase their flowers and planting. (Use visualiser so class can see)</p> <p>The rest of the class have the opportunity to agree/ disagree with each groups planting choices.</p> <p>Thumbs up/ down</p>	<p>I think it was a good idea that they planted their flowers their because ... If I was planting my flower in that park I would've planted it X instead</p>	<p>During this time informally assess the children's learning through their planting and reasoning.</p>	<p>Can each group justify their planting choices?</p> <p>Do others have a reasonable input of changes in other groups' choices?</p> <p>Are the flowers colourful/ have patterns?</p>

Appendix M2: Lesson 3 Powerpoint

Flower Planting with Bobby



Colour in Flowers



Pattern in Flowers



Dark vs Bright



Bun Case Flowers



Appendix N: Research Lesson 1 - Cycle 4

Lesson 4: Flight of the Bumblebee

STEAM Challenge: Compose your own ‘Flight of the Bumblebee’ using a variety of materials

Class: Senior Infants

Time: 40 minutes

Strand: Music - Listening and Responding

Science - Energy and Forces

Strand Unit: Music - Exploring Sounds,

- Listening and Responding to Music

Science - Sound

Lesson: *Exploring sound through use of materials and composing own bumblebee flight*

Curricular Objectives:

The child will be enabled to:

- ❖ Discover ways of making sounds using body percussion
- ❖ Listen to a range of short pieces of music or excerpts
- ❖ Respond imaginatively to short pieces of music through movement
- ❖ Recognise and show the difference between fast and slow tempos
- ❖ Recognise and show the difference between loud and soft sounds

The child will be enabled to:

- ❖ Identify and differentiate between high and low sounds, loud and soft sounds
- ❖ Explore ways of making different sounds using a variety of materials **Materials/**

Resources:

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>The teacher will ask the children to close their eyes and listen to see if they can figure out <i>what animal or insect this music reminds them of</i>. The teacher will then play an excerpt from ‘The Flight of the Bumblebee’.</p> <p>When finished the children will open their eyes and the teacher will take answers to the focus question.</p> <p>What sound does a bee make? Link to phonics ‘z’</p>	<p>Bee Fly Cat None I don’t know</p> <p>Zzzzz Buzzzz I don’t know None</p>	<p>Remind the children to listen and close their eyes. Make sure the video is not on the screen.</p> <p>Be open to all answers and ask for reasons why they think it's that animal/ insect.</p>	<p>Can they link the music to an animal/ insect and justify it?</p>

Development 1

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>Play the video and allow the children to watch it this time. Set the focus question <i>'How do you think the bee is feeling at different times?'</i></p> <p>When the video finishes, discuss the question.</p> <p>Make the sounds of a happy bee, then an angry bee.</p> <p>The children stand up and imitate the movement of the bee, running on the spot for fast/ slow.</p> <p>The children come into a circle.</p> <p>The teacher explains that using your body to make sounds is called body percussion eg. using our voice to make a buzz sound.</p> <p>The children then try out different body parts to make other sounds that sound like a bee.</p>	<p>Happy, angry, mad, scared I don't know</p>	<p>Model for the children</p> <p>I think the bee is feeling angry here because the buzzing gets louder.</p>	<p>Can the class connect feelings with the changes in the music?</p> <p>Do they get louder and faster with the sounds to represent an angry bee?</p> <p>Do they do softer and slower sounds to show the bee is happy?</p> <p>Can they do this without watching the video?</p> <p>Are they able to come up with suitable body percussion ideas?</p>

Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Percussion instruments are then introduced. The children are shown how to use the instruments.</p> <p>The children are then divided into groups of 4/5. In their groups they must decide which instruments most sound like a bee.</p> <p>They then in their groups compose their own 'Flight of the Bumblebee'.</p> <p>The groups perform</p>	<p>How do I use that? Can I do this instead?</p>	<p>Percussion instruments make a sound when hit, shaken or scraped.</p>	<p>Do the children engage with the instruments?</p> <p>Can they use the instruments to make bee like sounds?</p> <p>Can they compose a short flight of the bumblebee piece in groups?</p> <p>Are they willing to</p>
<p>their composition or show the sounds that they can make for the class. The teacher records the sound.</p>			<p>perform?</p>

Conclusion

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>The teacher plays back the compositions/sounds.</p> <p align="center"><u>Questioning</u></p> <p>Is the bee happy/angry now?</p> <p>What is body percussion?</p> <p>What is a percussion instrument?</p> <p>How do we hear sounds?</p>	<p>The bee is happy when the sound is soft and slow.</p> <p>The bee is angry when the sound is loud and fast.</p> <p align="center">I don't know</p> <p>Body percussion is making sounds with your body. Percussion instruments make sounds when hit, shaken and scratched.</p> <p align="center">Ear</p>	<p>Happy - soft and slow</p> <p>Angry - Loud and fast</p>	<p>Can they answer the informal assessment questions?</p>

Appendix N1: Research Lesson 2 - Cycle 4

Revised Lesson Plan Lesson 4: Flight of the Bumblebee

STEAM Challenge: Compose your own 'Flight of the Bumblebee' using a variety of materials

Class: Senior Infants

Time: 40 minutes

Strand: Music - Listening and Responding

Science - Energy and Forces

Strand Unit: Music - Exploring Sounds,

- Listening and Responding to Music

Science - Sound

Lesson: *Exploring sound through use of materials and composing own bumblebee flight*

Curricular Objectives:

The child will be enabled to:

- ❖ Discover ways of making sounds using body percussion
- ❖ Listen to a range of short pieces of music or excerpts
- ❖ Respond imaginatively to short pieces of music through movement
- ❖ Recognise and show the difference between fast and slow tempos
- ❖ Recognise and show the difference between loud and soft sounds

The child will be enabled to:

- ❖ Identify and differentiate between high and low sounds, loud and soft sounds

- ❖ Explore ways of making different sounds using a variety of materials **Materials/**

Resources:

Powerpoint, Youtube video <https://www.youtube.com/watch?v=X14kC-sEH0I>,

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>The teacher will ask the children to close their eyes and listen to see if they can figure out <i>what animal or insect this music reminds them of</i>. The teacher will then play an excerpt from ‘The Flight of the Bumblebee’.</p> <p>When finished the children will open their eyes and the teacher will take answers to the focus question.</p> <p>What sound does a bee make? Link to phonics ‘z’</p>	<p>Bee Fly Cat None I don’t know</p> <p>Zzzzz Buzzzz I don’t know None</p>	<p>Remind the children to listen and close their eyes. Make sure the video is not on the screen.</p> <p>Be open to all answers and ask for reasons why they think it's that animal/ insect.</p>	<p>Can they link the music to an animal/ insect and justify it?</p>

Development 1

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Play the video and allow the children to watch it this time. Set the focus question <i>'How do you think the bee is feeling at different times?'</i></p> <p>When the video finishes, discuss the question.</p> <p>Make the sounds of a happy bee, then an angry bee.</p> <p>The children stand up and imitate the movement of the bee, running on the spot for fast/ slow.</p> <p>The children come into a circle.</p> <p>The teacher explains that using your body to make sounds is called body percussion eg. using our voice to make a buzz sound.</p> <p>The children then try out different body parts to make other sounds that sound like a bee.</p>	<p>Happy, angry, mad, scared I don't know</p>	<p>Model for the children</p> <p>I think the bee is feeling angry here because the buzzing gets louder.</p>	<p>Can the class connect feelings with the changes in the music?</p> <p>Do they get louder and faster with the sounds to represent an angry bee?</p> <p>Do they do softer and slower sounds to show the bee is happy?</p> <p>Can they do this without watching the video?</p> <p>Are they able to come up with suitable body percussion ideas?</p>

Development 2

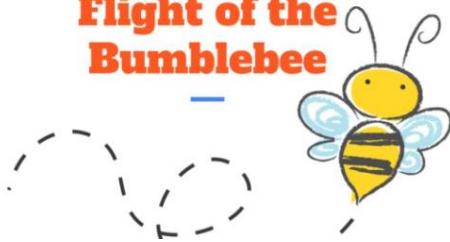
<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Percussion instruments are then introduced.</p> <p>The children are shown how to use the instruments.</p> <p>The children are then divided into groups of 4/5. In their groups they must decide which instruments most sound like a bee.</p> <p>They then in their groups compose their own 'Flight of the Bumblebee'.</p> <p>The groups perform</p>	<p>How do I use that? Can I do this instead?</p>	<p>Percussion instruments make a sound when hit, shaken or scraped.</p>	<p>Do the children engage with the instruments?</p> <p>Can they use the instruments to make bee like sounds?</p> <p>Can they compose a short flight of the bumblebee piece in groups?</p> <p>Are they willing to</p>
<p>their composition or show the sounds that they can make for the class. The teacher records the sound.</p>			<p>perform?</p>

Conclusion

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>The teacher plays back the compositions/sounds.</p> <p style="color: red;">The children comment on what they liked or would do differently if they were to do it again.</p> <p style="text-align: center;"><u>Questioning</u></p> <p>Is the bee happy/angry now?</p> <p>What is body percussion?</p> <p>What is a percussion instrument?</p> <p>How do we hear sounds?</p>	<p>The bee is happy when the sound is soft and slow.</p> <p>The bee is angry when the sound is loud and fast.</p> <p>I don't know</p> <p>Body percussion is making sounds with your body. Percussion instruments make sounds when hit, shaken and scratched.</p> <p style="text-align: center;">Ear</p>	<p>Happy - soft and slow</p> <p>Angry - Loud and fast</p>	<p>Can they answer the informal assessment questions?</p>

Appendix N2: Lesson 4 Powerpoint

Flight of the Bumblebee



Flight of the Bumblebee

<https://www.youtube.com/watch?v=X14kC-sEH0I>

Body Percussion



Percussion Instruments



Appendix O: Research Lesson 1 - Cycle 5

Lesson 5: Hexagon Honeycomb

STEAM Challenge: Create a digital story book for Bobby, showing other hexagons in the environment.

Class: Senior Infants

Time: 50 minutes

Strand: Mathematics - Shape and Space

Technology - ipads

Strand Unit: Maths - 2D shapes

Technology - using book creator app to create a digital book on hexagons

Lesson: Create a digital book on hexagons

Curricular Objectives:

The child will be enabled to:

- ❖ solve problems involving shape and space
- ❖ combine and divide 2-D shapes to make larger or smaller shapes
- ❖ recognise mathematics in the environment

The child will be enabled to:

- ❖ Develop 21st century skills: counting, sequencing, problem solving, estimating, directionality and vocabulary.

- ❖ Create a digital book using the book creator app on ipads **Materials/ Resources:**

Powerpoint, ipads, hexagons/ non hexagons in the environment images, sticks, marshmallows

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
Show the children an image on the board. T/P/S - what could this image be of?	Beehive Pattern I don't know	Welcome all guesses. Encourage imagination. It is a beehive!	Do the children think imaginatively? Is a picture an effective stimulus?

Development 1

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Tell the children that the shape is called a hexagon. Get them to say the word and clap the syllables.</p> <p>Use PP to discuss the hexagon shape - 6 sides Compare it to a square/ triangle/ circle, rectangle for sides and corners</p> <p>Ask 'why do you think bees use the hexagon shape in their hives?' Show the video - focus for video why do bees use hexagon shape in their hives.</p>	<p>It has more sides than a _____</p> <p>It has less sides than a _____</p> <p>They look different I don't know</p> <p>Because they like it It helps store the honey I don't know</p>	<p>Focus for hexagon on number on sides Revision of 2D shapes</p> <p>Bees use hexagons to save wax, space and to make the hive strong.</p>	<p>Can they discuss sides, corners etc? Can they name and revise 2d shapes?</p> <p>Do they understand bees use the hexagon to save wax, not to waste space and because it makes the hives strong?</p>

Development 2

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>

<p>Tell the children they are now going to make hexagons using sticks and marshmallows.</p> <p>Put the children in pairs and distribute sticks and marshmallows.</p> <p>When they have all made a hexagon, get them to try to make a bigger hexagon. Try make honeycomb</p>	<p>Yay I don't know how</p>	<p>Circulate and support pairs that need it.</p> <p>Support - Why don't you try using more sticks?</p>	<p>Are they able to make a hexagon?</p> <p>Do they work well in pairs?</p> <p>Can they grasp the idea of using more sticks to make a bigger hexagon?</p> <p>Can they tessellate the shapes?</p>
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Development 3

<p><u>Learning Activities and Questions</u></p>	<p><u>Expected Student Reactions</u></p>	<p><u>Teacher Response & Things to Remember</u></p>	<p><u>Evaluation</u></p>
<p>Have images of hexagons/ non hexagons placed around the room.</p> <p>Tell them that in their pairs they need to go hunt around the room to find the pictures of hexagons in the environment and take a picture of them using the ipad.</p> <p>When they return to their tables after finding the hexagon images, tell them about the book creator app.</p> <p>In their pairs children create a digital book using the images they took.</p>	<p>Yay How do you take pictures on an ipad?</p>	<p>Place the images around the room prior to the lesson.</p> <p>Demonstrate how to take a picture using an ipad.</p> <p>Show them the book creator app on the IWB - how to add photos, text etc.</p> <p>Encourage them to be creative and try out different features/ label their images etc.</p>	<p>Are they able to recognise hexagons?</p> <p>Are they able to use the ipads?</p> <p>Do they enjoy using the ipads?</p> <p>How capable of using the book creator app are they?</p> <p>Do they explore different features?</p>

Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Children can move from group to group and see other pair's books.</p> <p>Whole class discussion</p> <p>Did you see anything that other people did that you liked?</p> <p>If you were making a book again is there anything you would do differently?</p> <p>What was your favourite thing about your book?</p>	<p>I liked X about their book</p> <p>I would change the colour</p> <p>Nothing</p>	<p>Encourage reasoning by asking 'why'</p>	<p>Were all pairs able to make a book?</p> <p>Were they able to notice features of different books?</p> <p>Do they know what a hexagon is?</p>

Appendix O1: Research Lesson 2 - Cycle 5

Revised Lesson Plan Lesson 5: Hexagon Honeycomb

STEAM Challenge: Create a digital story book for Bobby, showing other hexagons in the environment.

Class: Senior Infants

Time:

Strand: Mathematics - Shape and Space

Technology - ipads

Strand Unit: Maths - 2D shapes

Technology - using book creator app to create a digital book on hexagons

Lesson: Create a digital book on hexagons

Curricular Objectives:

The child will be enabled to:

- ❖ solve problems involving shape and space
- ❖ combine and divide 2-D shapes to make larger or smaller shapes
- ❖ recognise mathematics in the environment

The child will be enabled to:

- ❖ Develop 21st century skills: counting, sequencing, problem solving, estimating, directionality and vocabulary.
- ❖ Create a digital book using the book creator app on ipads **Materials/ Resources:**

Powerpoint, ipads, hexagons/non hexagons in the environment images, sticks, playdough

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
Show the children an image on the board. T/P/S - what could this image be of?	Beehive Pattern I don't know	Welcome all guesses. Encourage imagination. It is a beehive!	Do the children think imaginatively? Is a picture an effective stimulus?

Development 1

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Gather the children in a circle in front of the IWB. Tell the children that the shape is called a hexagon. Get them to say the word and clap the syllables.</p> <p>Use PP to discuss the hexagon shape - 6 sides Compare it to a square/ triangle/ circle, rectangle for sides and corners</p> <p>Ask 'why do you think bees use the hexagon shape in their hives?' Show the video - focus for video why do bees use hexagon shape in their hives.</p>	<p>It has more sides than a _____</p> <p>It has less sides than a _____</p> <p>They look different I don't know</p> <p>Because they like it It helps store the honey I don't know</p>	<p>Focus for hexagon on number on sides Revision of 2D shapes</p> <p>Bees use hexagons to save wax, space and to make the hive strong.</p>	<p>Can they discuss sides, corners etc? Can they name and revise 2d shapes?</p> <p>Do they understand bees use the hexagon to save wax, not to waste space and because it makes the hives strong?</p>

Development 2

<u>Learning Activities and</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to</u>	<u>Evaluation</u>
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<u>Questions</u>		<u>Remember</u>	
<p>Tell the children they are now going to make hexagons using sticks and playdough.</p> <p>Put the children in pairs and distribute sticks and playdough.</p> <p>When they have all made a hexagon, get them to try to make a bigger hexagon. Try make honeycomb</p>	<p>Yay I don't know how</p>	<p>Circulate and support pairs that need it.</p> <p>Support - Why don't you try using more sticks?</p>	<p>Are they able to make a hexagon?</p> <p>Do they work well in pairs?</p> <p>Can they grasp the idea of using more sticks to make a bigger hexagon?</p> <p>Can they tessellate the shapes?</p>

Development 3

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Have images of hexagons/ non hexagons placed around the room.</p> <p>Tell them that in their pairs they are going on a hunt around the room. The challenge is to find pictures of hexagons in the environment and take a picture of them using the ipad.</p> <p>Beware of other 2D shapes that might trick you!</p> <p>When they return to their tables after finding the hexagon images, show images on the board and briefly discuss.</p>	<p>Yay How do you take pictures on an ipad?</p>	<p>Place the images around the room prior to the lesson.</p> <p>Demonstrate how to take a picture using an ipad.</p> <p>Show them the book creator app on the IWB - how to add photos, text etc.</p> <p>Encourage them to be creative and try out different features/ label their images etc.</p>	<p>Are they able to recognise hexagons?</p> <p>Are they able to use the ipads?</p> <p>Do they enjoy using the ipads?</p> <p>How capable of using the book creator app are they?</p> <p>Do they explore different features?</p>

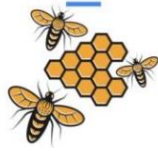
<p>Then tell them about the book creator app. Briefly run through the features with aid of PP.</p> <p>In their pairs children create a digital book using the images they took.</p>			
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Conclusion

<p><u>Learning Activities and Questions</u></p>	<p><u>Expected Student Reactions</u></p>	<p><u>Teacher Response & Things to Remember</u></p>	<p><u>Evaluation</u></p>
<p>Children can move from group to group and see other pair's books.</p> <p>Whole class discussion</p> <p>Did you see anything that other people did that you liked?</p> <p>If you were making a book again is there anything you would do differently?</p> <p>What was your favourite thing about your book?</p>	<p>I liked X about their book</p> <p>I would change the colour</p> <p>Nothing</p>	<p>Encourage reasoning by asking 'why'</p>	<p>Were all pairs able to make a book?</p> <p>Were they able to notice features of different books?</p> <p>Do they know what a hexagon is?</p>

Appendix O2: Lesson 5 Powerpoint

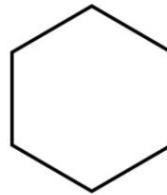
Hexagon Honeycomb



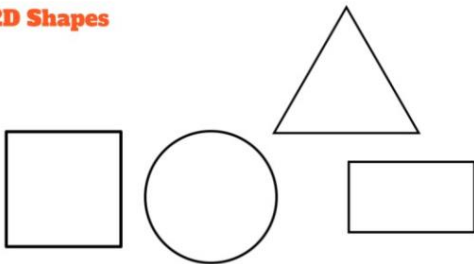
Honeycomb and Bees



Hexagon



2D Shapes

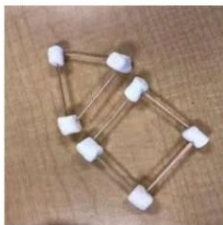


Beehives

<https://www.youtube.com/watch?v=QozEYZoFCwk>



2D shape construction



Hexagons in the Environment



Book Creator App



Appendix P: Research Lesson 1 - Cycle 6

Lesson 6: To Bee or not to Bee

STEAM Challenge: Come up with solutions to help save Bobby and the bees, through role play.

Class: Senior Infants

Time: 40 minutes

Strand: Drama - Drama to explore feelings, knowledge and ideas, leading to understanding
Science - Environmental Awareness and Care

Strand Unit: Drama - Exploring and Making Drama, Reflecting on Drama, Co-operating and Communicating in Making Drama
Science - Caring for my Locality

Lesson: Discuss the role of beekeepers and how we can help save the bees

Curricular Objectives:

The child will be enabled to:

- ❖ Develop the ability to play in role as an integral part of the action.
- ❖ Develop awareness of the tension in the drama
- ❖ Share insights gained while experiencing the drama
- ❖ Develop the ability, out of role, to co-operate and communicate with others in helping to shape the drama.

The child will be enabled to:

- ❖ Develop a sense of responsibility for taking care of and improving the environment
- ❖ Identify and discuss simple strategies for improving and taking care of the environment.

Materials/ Resources: PP

Introduction

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Walkabout: We are going to walk around the room at different speeds and when I say “Freeze” you must freeze on the spot. The number 5 is our normal pace which we generally walk at, 6 a little faster, 7 a little faster again all the way up to ten. Ten is walking fast, NOT running. Likewise 4 a little slower, 3 a little slower again and so on. Next we will continue walking at our normal pace; 5 and this time I want you to walk as if you were walking through: A field of mud. Hot sand. Paddling through water. And finally a field of the most beautiful flowers you’ve ever seen. How will you walk through this field? Can you feel and smell the flowers?</p> <p>After the game the children will come sit at the top of the room. I will ask: Does anyone remember Bobby? Where does he live? How would you walk</p>	<p>Children enjoying game</p> <p>Children not enjoying game/ not engaging</p>	<p>Explain game clearly before starting.</p> <p>Remind children of rules during the game if necessary.</p>	<p>Do the children enjoy the game?</p> <p>Do they think of protecting flowers/ beehives when in a park with bees?</p>

through a park with bees?			
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Development 1

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Explain that bees are very important as they help make the food we eat and help to grow flowers. (link to pollination) Without bees we would have no fruit or vegetables!</p> <p>Focus question; why are bees in danger? Play the video of the beekeeper talking about why bees are in danger. -chemicals -habitat loss - humans</p> <p>Ask the class if they want to know how to help save the bees?</p> <p><u>Teacher in Role</u> The teacher tells the class that when she/he puts on the beekeeper hat that she/he becomes a beekeeper and they can ask her questions</p>	<p>Bees are important to make honey/ for flowers/ pollination I don't know</p> <p>Bees are in danger because of humans, chemicals, habitat loss I don't know</p> <p>Yes! No</p> <p>How can I help save bees? How do you feel? Why do people put bees in danger?</p>	<p>Encourage answers. Give examples of fruit/veg they help make - tomatoes, broccoli</p> <p>If children are struggling to come up with questions give support/ ideas they could ask</p> <p>Teacher at this time gives ideas on how to save the bees.</p>	<p>Do they have any current knowledge on why bees are important from previous lessons?</p> <p>Is the video engaging?</p> <p>Are they interested in helping to save bees?</p> <p>Do they comprehend - teacher in role? Are they engaged?</p>

Development 2

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>Creating a still image The teacher will ask</p> <p>for 3 volunteers. The teacher will position the children and demonstrate making a still image and adding a sentence.</p> <p>The children will be put into groups of 4 and asked to create a still image showing how they will help save the bees. They will be asked to come up with one sentence each.</p> <p align="center">Performing</p> <p>Each group will be asked to come to the top of the classroom and on the count of three they will show their first image. Then on the count of 3 they will each say their sentence.</p> <p>The images will be discussed on the basis of how well they tell the story and what is it about their still image that tells the story well.</p>	<p>I will volunteer!</p> <p>Not me!</p> <p>I don't know what to do I can do it I have an idea</p> <p>I don't want to perform Can we go next?</p> <p>I like the way that group did.... To show how they would ...</p>	<p>Explain that a still image is frozen and does not involve moving. Demonstrate a still image and then the addition of a simple sentence.</p> <p>Encourage the children. Circulate the room to support.</p> <p>Say what you like about each groups still image or elicit other ideas what they could have done or would do next time. Praise!</p>	<p>Does the demonstration explain clearly what is expected of them?</p> <p>Are they able to create a still image and add a sentence? Are all group members getting involved? Do they have an idea on how they can help save the bees?</p> <p>Are they confident in performing?</p> <p>Are their images/ sentences creative?</p>

Development 3

<p style="text-align: center;"><u>Learning Activities and Questions</u></p>	<p style="text-align: center;"><u>Expected Student Reactions</u></p>	<p style="text-align: center;"><u>Teacher Response & Things to Remember</u></p>	<p style="text-align: center;"><u>Evaluation</u></p>
<p>Hot Seating A scenario is then introduced:</p> <p>There is going to be a new restaurant built in the park. The builders</p> <p>want to build it for money but the beekeeper does not want it to be built because it means destroying lots of flowers and beehives.</p> <p>Teacher asks for 3 volunteers; Bobby, the beekeeper, the builder. Each volunteer is hot seated and questioned by the other pupils.</p> <p>Discussion generated on whether or not the restaurant should be built.</p>	<p>Why don't you build the restaurant somewhere else?</p> <p>How do you feel?</p> <p>I think it should be built because...</p> <p>I don't think it should be built because...</p>	<p>Support children in hot seat if they are struggling.</p> <p>Input where necessary to aid understanding.</p>	<p>Do they grasp the concept of hot seating?</p> <p>Can children in role engage appropriately and justify reasons?</p> <p>Do the children ask appropriate questions?</p>

Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Question the children on what they did today. What is a still image? Do you think still images can help to show the story? Is it easy or hard to show a story without talking?</p> <p>Why are bees so important? Why are they in danger? What can we do to help?</p>	<p>A still image is a frozen image. Yes It is hard because... It is easy because...</p> <p>Bees help us make honey/ food/ flowers</p> <p>They are in danger because of chemicals/ humans</p> <p>We can plant a bee garden, go wild, no chemicals, plant trees, plant flowers, don't kill bees, recycle</p>	<p>Observe student answers for assessment.</p> <p>Address any misconceptions</p>	<p>Can they answers questions correctly?</p>

Appendix P1: Research Lesson 2 - Cycle 6

Revised Lesson Plan Lesson 6 : To Bee or not to Bee

STEAM Challenge: Come up with solutions to help save Bobby and the bees, through role play.

Class: Senior Infants

Time: 40 minutes

Strand: Drama - Drama to explore feelings, knowledge and ideas, leading to understanding

Science - Environmental Awareness and Care

Strand Unit: Drama - Exploring and Making Drama, Reflecting on Drama, Co-operating and

Communicating in Making Drama

Science - Caring for my Locality

Lesson: Discuss the role of beekeepers and how we can help save the bees

Curricular Objectives:

The child will be enabled to:

- ❖ Develop the ability to play in role as an integral part of the action.
- ❖ Develop awareness of the tension in the drama
- ❖ Share insights gained while experiencing the drama
- ❖ Develop the ability, out of role, to co-operate and communicate with others in helping to shape the drama.

The child will be enabled to:

- ❖ Develop a sense of responsibility for taking care of and improving the environment
- ❖ Identify and discuss simple strategies for improving and taking care of the environment.

Materials/ Resources: PP

Introduction

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>Walkabout: We are going to walk around the room at different speeds and when I say “Freeze” you must freeze on the spot. The number 5 is our normal pace which we generally walk at, 6 a little faster, 7 a little faster again all the way up to ten. Ten is walking fast, NOT running. Likewise 4 a little slower, 3 a little slower again and so on. Next we will continue walking at our normal pace; 5 and this time I want you to walk as if you were walking through: A field of mud. Hot sand. Paddling through water. And finally a field of the most beautiful flowers you’ve ever seen. How will you walk through this field? Can you feel and smell the flowers?</p> <p>After the game the children will come sit at the top of the room. I will ask: Does anyone remember Bobby? Where does he live?</p>	<p align="center">Children enjoying game</p> <p align="center">Children not enjoying game/ not engaging</p>	<p align="center">Explain game clearly before starting.</p> <p align="center">Remind children of rules during the game if necessary.</p>	<p align="center">Do the children enjoy the game?</p> <p align="center">Do they think of protecting flowers/ beehives when in a park with bees?</p>
<p>How would you walk through a park with bees?</p>			

Development 1

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Recap learning from previous lessons on why bees are very important as they help make the food we eat and help to grow flowers. (link to pollination)</p> <p>Focus question; why are bees in danger? Play the video of the beekeeper talking about why bees are in danger. -chemicals -habitat loss - humans</p> <p>Ask the class if they want to know how to help save the bees?</p> <p><u>Teacher in Role</u> The teacher tells the class that when she/he puts on the beekeeper hat that she/he becomes a beekeeper and they can ask her questions</p>	<p>Bees are important to make honey/ for flowers/ pollination I don't know</p> <p>Bees are in danger because of humans, chemicals, habitat loss I don't know</p> <p>Yes! No</p> <p>How can I help save bees? How do you feel? Why do people put bees in danger?</p>	<p>Without bees we would have no fruit or vegetables! Encourage answers. Give examples of fruit/veg they help make - tomatoes, broccoli</p> <p>If children are struggling to come up with questions give support/ ideas they could ask</p> <p>Teacher at this time gives ideas on how to save the bees.</p>	<p>Do they have any current knowledge on why bees are important from previous lessons?</p> <p>Is the video engaging?</p> <p>Are they interested in helping to save bees?</p> <p>Do they comprehend - teacher in role? Are they engaged?</p>

Development 2

<u>Learning</u>	<u>Expected Student</u>	<u>Teacher Response</u>	<u>Evaluation</u>
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<u>Activities and Questions</u>	<u>Reactions</u>	<u>& Things to Remember</u>	
<p>Creating a still image The teacher will ask for 3 volunteers. The teacher will position the children and demonstrate making a still image and adding a sentence.</p> <p>The children will be put into groups of 4 and asked to create a still image showing how they will help save the bees. They will be asked to come up with one sentence each.</p> <p>Performing Each group will be asked to come to the top of the classroom and on the count of three they will show their first image. Then on the count of 3 they will each say their sentence.</p> <p>The images will be discussed on the basis of how well they tell the story and what is it about their still image that tells the story well.</p>	<p>I will volunteer! Not me!</p> <p>I don't know what to do I can do it I have an idea</p> <p>I don't want to perform Can we go next?</p> <p>I like the way that group did.... To show how they would ...</p>	<p>Explain that a still image is frozen and does not involve moving. Demonstrate a still image and then the addition of a simple sentence.</p> <p>Encourage the children. Circulate the room to support.</p> <p>Say what you like about each groups still image or elicit other ideas what they could have done or would do next time. Praise!</p>	<p>Does the demonstration explain clearly what is expected of them?</p> <p>Are they able to create a still image and add a sentence? Are all group members getting involved? Do they have an idea on how they can help save the bees?</p> <p>Are they confident in performing?</p> <p>Are their images/ sentences creative?</p>

Development 3

<p align="center"><u>Learning Activities and Questions</u></p>	<p align="center"><u>Expected Student Reactions</u></p>	<p align="center"><u>Teacher Response & Things to Remember</u></p>	<p align="center"><u>Evaluation</u></p>
<p>Hot Seating A scenario is then introduced:</p> <p>There is going to be a new restaurant built in the park. The builders want to build it for money but the beekeeper does not want it to be built because it means destroying lots of flowers and beehives.</p> <p>Teacher asks for 3 volunteers; Bobby, the beekeeper, the builder. Each volunteer is hot seated and questioned by the other pupils.</p> <p>Discussion generated on whether or not the restaurant should be built.</p>	<p>Why don't you build the restaurant somewhere else?</p> <p>How do you feel?</p> <p>I think it should be built because...</p> <p>I don't think it should be built because...</p>	<p>Support children in hot seat if they are struggling.</p> <p>Input where necessary to aid understanding.</p>	<p>Do they grasp the concept of hot seating?</p> <p>Can children in role engage appropriately and justify reasons?</p> <p>Do the children ask appropriate questions?</p>

Conclusion

<u>Learning Activities and Questions</u>	<u>Expected Student Reactions</u>	<u>Teacher Response & Things to Remember</u>	<u>Evaluation</u>
<p>Question the children on what they did today. What is a still image? Do you think still images can help to show the story? Is it easy or hard to show a story without talking?</p> <p>Why are bees so important? Why are they in danger? What can we do to help?</p>	<p>A still image is a frozen image. Yes It is hard because... It is easy because...</p> <p>Bees help us make honey/ food/ flowers</p> <p>They are in danger because of chemicals/ humans</p> <p>We can plant a bee garden, go wild, no chemicals, plant trees, plant flowers, don't</p>	<p>Observe student answers for assessment.</p> <p>Address any misconceptions</p>	<p>Can they answer questions correctly?</p>
	<p>kill bees, recycle</p>		

Appendix P2: Lesson 6 Powerpoint

To Bee or not to Bee



Why are bees so important?



Beekeeper

https://www.google.com/search?scn_esv=560494483&sxsrf=AB5stBgvXU8WbCurQ1r3x5D1kP9q4qIG7Q:169314525141&q=beekeeper+on+why+bees+are+so+important&tbm=vid&source=inms&sa=X&ved=2ahUKFwixp4_Kqf2AAxVnWEEAHXerBKsQ0pQJeqQIDRAB&biw=1366&bih=651&dpr=1#fpstate=ive&vid=cid:e175ed4e.vid:z9z48jJZyk



Appendix Q: Lesson Observation Template

Lesson Observation

Lesson: _____

Teacher: _____

Date: _____

Engagement	
Participation	
Effective Features of the Lesson	
Areas for change/ consideration	
Evident Learning	
Assessment	

Appendix Q1: Worked Example of Lesson Observation Template

Lesson Observation
↳ Beebots

Lesson: 1-cycle2
Teacher: Jamie (P2)
Date: Feb 2023

Engagement ✓ v. excited for beebots	- loved video
Participation - v. eager to have turn, didn't wait to wait	- arguing over who's going first
Effective Features of the Lesson	Video Small groups Recep PP - for support!
Areas for change/ consideration Puppet? - no story	are code cards necessary? ↳ messy trying to keep Timing!!! * child demo?
Evident Learning	Collaboration ✓ Reasoning ✓ Communication ✓ Creativity ✓ Predicting ✓ Leadership ✓
Assessment - could recep + discuss previous lesson.	WCD ✓

give numbers:

Too many objectives?? - living things?
* Bring back UT?
Draw own flower?
* When Bee stops press (X)

Appendix R: Excerpt from Researchers Observations

March 22nd 2023

In today's meeting 'Anna' made comments about having to go do her actual maths lesson tomorrow despite saying in her last interview that she sees the STEAM lessons as practical lessons now and feels like a high level of learning is achieved in the STEAM lessons.

Appendix S: Excerpt from Transcribed Interview

Interview: 2

Date: 29th March 2023

Time: 14:35

Interviewer:

Have your perceptions of steam changed?

Participant 1:

Yes, definitely. The first big change, I would notice. Well, first of all, I think in the first interview, I probably said I wasn't sure if you teach steam like science, then technology then engineering and I also would have said I thought it was just visual art but um, yeah, so I feel like I have a much clearer understanding of what a lesson steam lesson should look like. And the kind of benefits that do come from it more I think, yeah.

Interviewer:

What have you learned?

Participant 1:

I'm not gonna say I know how to do it perfectly but I have a much better idea of how to plan a steam lesson. So I've learned to focus on two and then whatever if more integrate in that's a bonus. And before I probably would have seen it as just a fun lesson like not a practical, everyday kind of one. So that for me has changed a lot by seeing the benefits and how engaging their finding the lessons. Another thing that really stood out to me actually one of them was when you were like they learn from failure and its okay to fail, we want them to try again and rethink like when they were doing the houses and you were like it's actually okay, it's good if they fail, because you want to see if they work together and solve the problem to it again. So that's not something that I would have really thought of before I suppose.

Interviewer:

Which lesson did you most enjoy or think was the best lesson why?

Participant 1:

I would definitely say the Beebots. I'm drawn to the Beebots maybe because I've never used them before and I just thought they were amazing. And like the kids for that lesson were oh my god they were so excited. Like I've never seen anything like that before. They were so engaged and I remember I was so sceptical before that lesson. I was like, Oh, I was like, I can't imagine them being able to use them but I think maybe sometimes, well this lesson kind of made me realise I think I underestimate the children a bit but yeah, I just found like for the whole lesson they were engaged. I just thought it has worked really, really well. And then to have it all linked in with pollination. I loved that lesson. Also it made me kind of realise I could use bee bots to teach other things now that I know what they are and how they work.

Appendix T: List of Raw Codes

Increase in teachers confidence in teaching STEAM

Progression in teachers understanding of STEAM

Progression in teachers value of STEAM

Effective resources in ECE STEAM

Challenges in teaching STEAM for teachers

Lesson study as a form of CPD - high levels of engagement and participation, long lasting results

Challenges of LS - Time consuming, confidence, resistance to change, resources

Benefits of LS - vehicle for change, support, collaboration, improved teaching and long term impact

Effective STEAM pedagogies in ECE

Teachers struggle with changing practice

Teachers struggle with confidence in STEAM

Integrating play in ECE STEAM

Technology as beneficial resource in ECE STEAM

STEAM supporting inclusive education

Effortless learning in ECE STEAM

Benefits of thematic approach and integration of disciplines

Increase in children's confidence

Benefits of inquiry based learning

Positive changes in pupils attitudes towards STEAM

Beebots as highly effective resource

Group work and puppet highly effective

Appendix U: A Worked Example of Thematic Analysis

Data Extract	Code
<p><i>What impact, if any, has your involvement in this project had on your perception of teaching STEAM?</i></p> <p>Initially I would have not been unsure whether you teach one discipline or what, actually I didn't think you'd teach one. I thought you had to teach them all in one lesson. And then if you have all five disciplines, integrated like I was like, where did you start? You know, I felt like back then you weren't fully covering anything. You know, it's just bits of everything. And I thought it would be so hard to include all of them in every lesson, so I couldn't see how it works. Whereas now, I've learned that that's not the case. I've also learned it's a way of including all learners in the classroom.</p> <p><i>Have you observed any changes in your pupils' attitudes to STEAM disciplines or STEAM since this project began?</i></p> <p>Yes definitely, you know, they are infants and I wouldn't, I suppose, have always said we're doing science. Now we're doing maths. You know, I wouldn't have I suppose explicitly said it. But some did have a negative attitude towards them before like you know, some kids behaviour would've changed during maths lessons. Particularly, you know, kids, like even infants some of them would feel they're not good at it or you know, kids that age they can still sense when others are stronger but since integrating those subjects with something else, I have noticed that all children are willing to participate in the lessons, are more engaged and have a lot more confidence in themselves. The content seemed more accessible to all because there wasn't the pressure to just complete sums.</p>	<p>Progression in teachers understanding of STEAM</p> <p>Progression in teachers knowledge of teaching STEAM</p> <p>Progression in teachers value of STEAM</p> <p>STEAM supporting inclusive education</p> <p>Developing children's confidence</p> <p>STEAM supporting inclusive education</p>

Appendix V: Grouping Initial Codes under Themes

Theme 1: Teacher's Progression of Understanding, Teaching and Value in ECE STEAM

Subtheme: Teacher's Confidence and Change in Practice as a Surmountable Barrier in ECE STEAM

Participant 1: 'I wouldn't be confident in teaching a STEAM or STEM lesson. To be honest it's not something that I have any experience with really. I'm kind of embarrassed to say that.' (Initial Interview)

Participant 2: 'I wouldn't be confident in teaching STEAM no. I'm grand with teaching the disciplines alone but integrating them is overwhelming.' (Initial Interview)

Participant 1: 'Planning together, having the lesson fresh in my head and seeing others teach it has been great in helping my confidence.' (Midway Interview)

Participant 2: 'Obviously when you're doing something new you're going to be nervous but honestly after the first lesson I felt much less nervous. Watching another teacher teach has been a fantastic opportunity for me. It helped calm my nerves, knowing what to expect in the first lesson especially.' (Midway Interview)

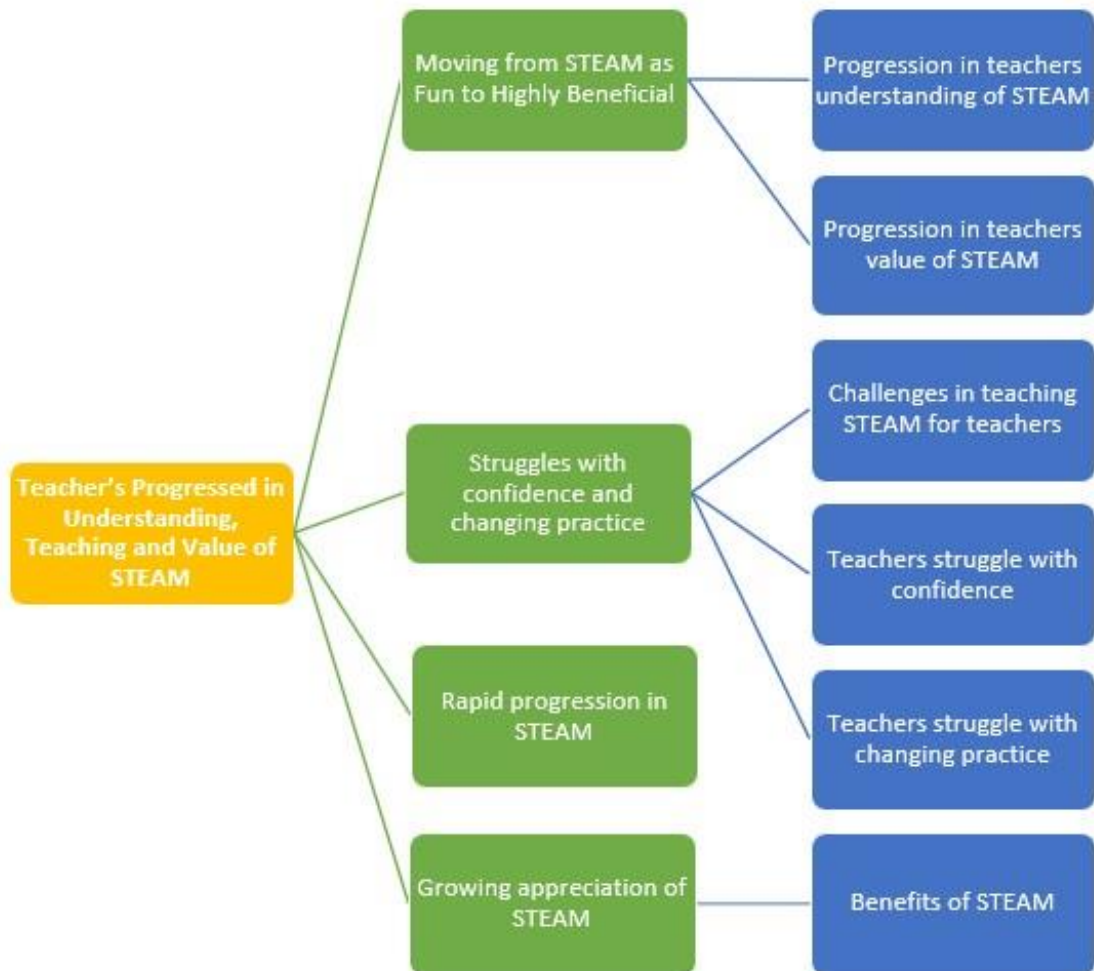
'I know our next lesson has a focus on drama which is something I probably don't teach enough of due to my own lack of knowledge or confidence in teaching it so this is something I'm nervous about.' (Midway Interview)

Participant 1: 'Focus on two disciplines.. ensure there is a lot of child centred learning.. allow the children a chance to fail and try again..group work is essential..use a timer!' (Final Interview)

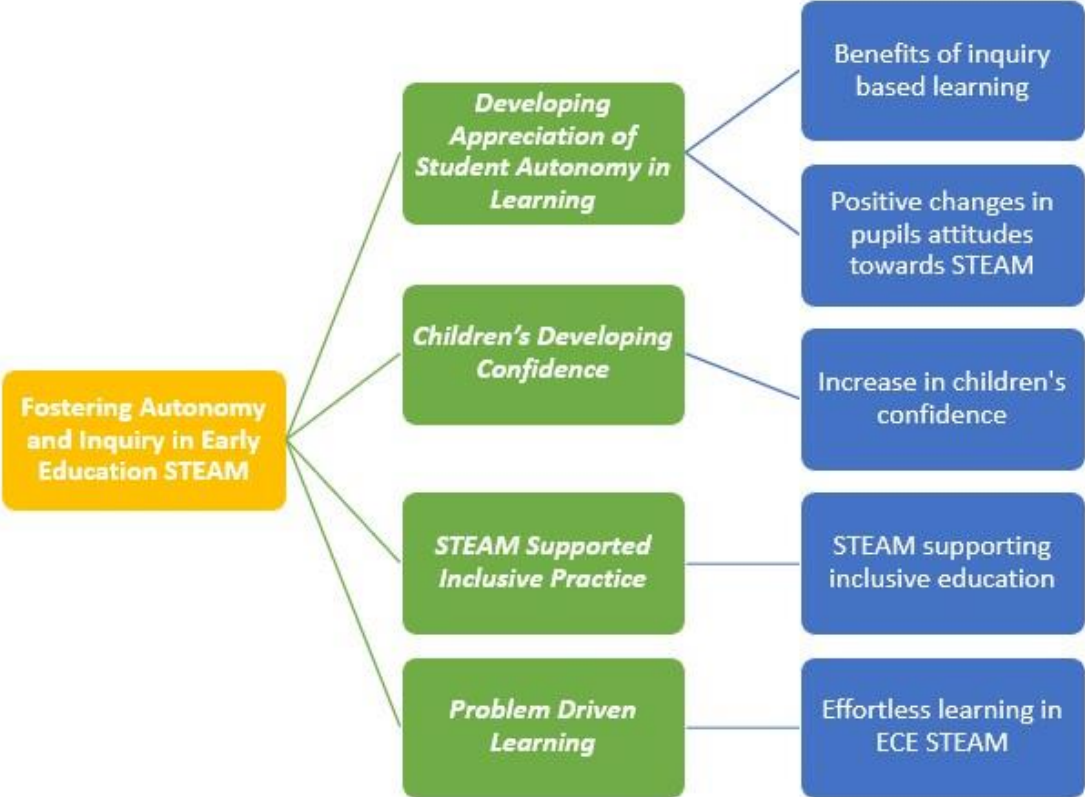
Participant 2: 'Don't be afraid of it! If you break it down and say pick a maths topic you need to teach, think what other discipline can I bring into it..once you have this the rest falls into place and kind of makes sense. As you make these connections your creative side kicks in and you actually become excited for the lesson!' (Final Interview)

Appendix W: Developing the Themes and Subthemes

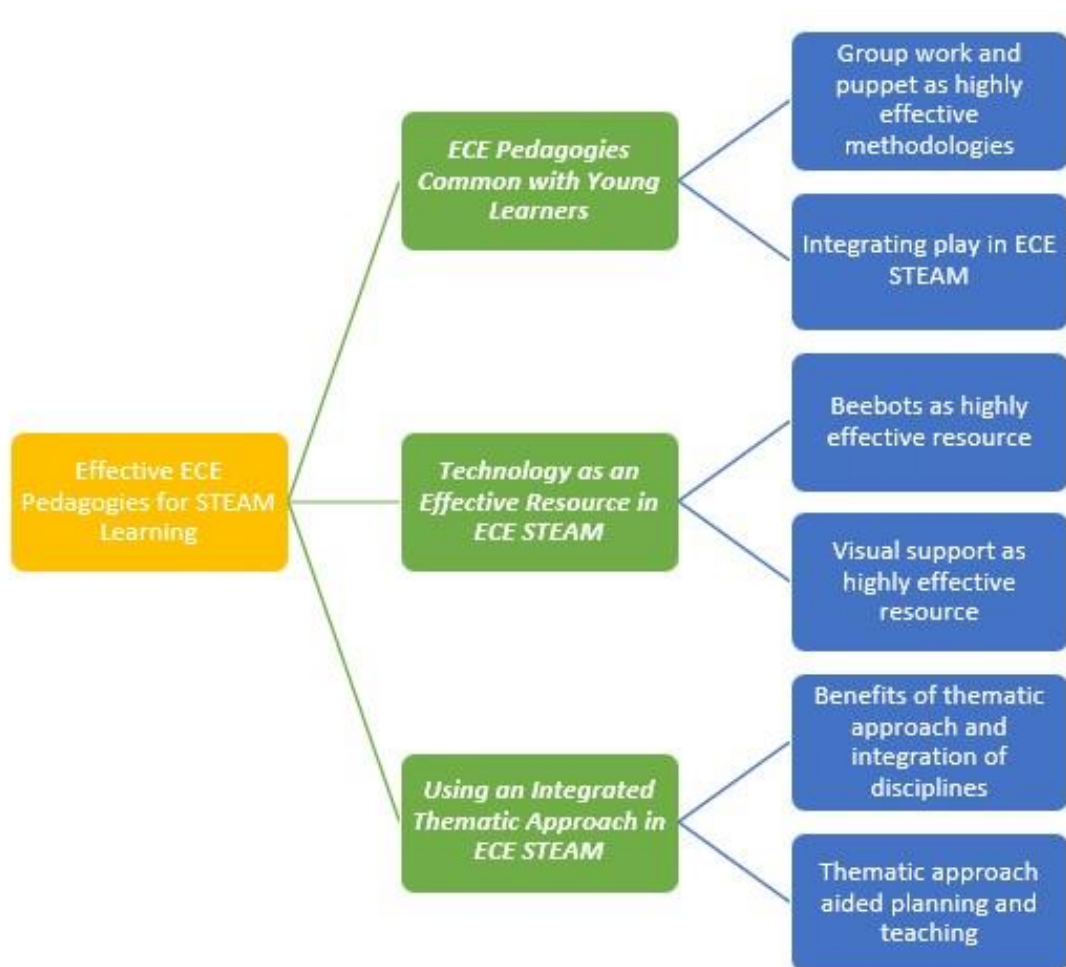
Theme 1: Progression in Understanding, Teaching and Valuing ECE STEAM



Theme 2: Fostering Autonomy and Inquiry in Early Education STEAM



Theme 3: Effective ECE Pedagogies for STEAM Learning



Theme 4: Navigating LS: Benefits and Challenges for Educators

